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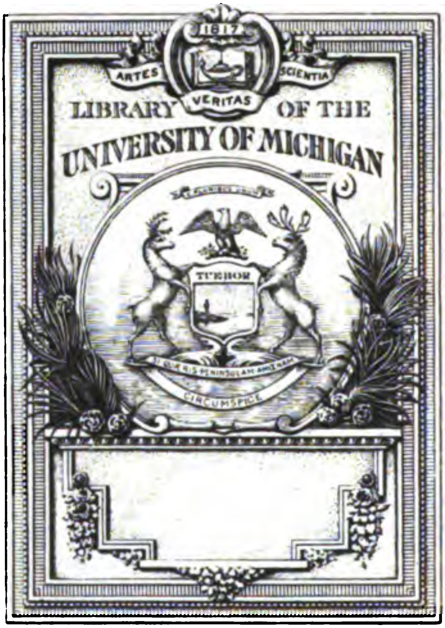
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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 131

SEPTEMBER, 1907

Commercial Feeding Stuffs

BURLINGTON:
FREE PRESS PRINTING CO.,
1907.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

General

BULLETIN 131.—COMMERCIAL FEEDING STUFFS

By J. L. Hills and C. H. Jones

One hundred and twelve samples of commercial feeding stuffs were drawn in the inspection of early spring of 1907. Half of these represented 45 brands of guarantied goods (by-products of the oil mills, glucose and breakfast food factories and the distilleries), and half were unguarantied feeds (wheat offals and home-grown provenders). These samples were tested for protein only, for reasons hitherto explained. The number of samples drawn (but half those usually taken) was diminished by the small amount of funds available from the State appropriation. Moreover, the supply on hand was extremely light.

RESULTS OF INSPECTION

The results of inspection of the guarantied goods are displayed on pages 7-8. These tables show the manufacturer's name, brand name, protein guaranty and analysis of each goods, together with a statement as to the general standing of each brand in the inspections of the past seven years; the comments being based on the success or non-success of guaranty maintenance. It should be understood, however, that guaranty maintenance, though desirable, is not the sole criterion by which a feed should be gaged. The phraseology at the right of each line of the tables in no way whatsoever attempts to group the goods as to their feeding values. It simply calls attention to the facts which the biennial inspections have developed as to the manner in which manufacturers have or have not kept their promises. No attempt is made to separate the high from the low, the rich from the poor, advisable from inadvisable purchases, but solely to measure performance against promise.

A few remarks touching the tabulated results seem in order.

Fourteen *cottonseeds* were sampled. Four (Dixie, Sun, Old Gold, Battle) made good the guaranty; two were almost up to guaranty statements (Hunter Bros.' Prime, Green Diamond); four (Owl, Star, Phoenix, Brodé Co.'s Pure) ranged from 1½ to 2½ percent below guaranty; two (Magnolia, Bridges) were seriously lacking, being 3½ to 4 percent short; one Hunter Bros.'

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Prime, separated from others of the same brands because of inferior appearance), was 5½ percent below promise[1]; and one, bearing the firm name Kaiser & Brown, marked "K. & B. Prime," contained but 20 percent protein against a 41 percent guaranty. Neither the jobbers nor the local dealer selling the K. & B. goods offer explanation or answer letters.

Five *distillers' grains* were found. Two (Ajax Flakes, Empire State) met guaranties; four (Ajax Flakes, Empire State and XX Grains) fell from a half to two percent short.

Union Grains, a mixture sold by a distillers' grains house, into which these goods largely enter, barely met guaranty.

One *oat feed* (Quaker) did, another (Schumaker) did not fulfil its guaranty statement. Two *hominy chops* just made good their promises.

Five *molasses feeds* were tested. Three (Sucrene Dairy, Sucrene Horse, Molac Horse), carried protein in excess of guaranty; one (Molac Dairy) barely met guaranty; one (Green Diamond Sugar) fell somewhat short.

One lot of *alfalfa meal,* the product of the Ralston Purina Mills, fell 2 percent below guaranty.

Two lots of *beef scraps* exceeded guaranty.

Twenty *mixed feeds,* five *brans,* fourteen *middlings* and a *red dog flour* were found to be of good grade, as were also five *provenders* of local manufacture.

CONCERNING THE COTTONSEED MEAL SITUATION

The poor quality of cottonseed meal offered in the season of 1906-07 has been notorious. Weather conditions during the late crop growing season seem to have been largely at fault, making it difficult at times for mills adequately to separate the hulls from the meats. Hence the product was very variable and more or less debased. The jobbers as a rule seem to have deplored the situation and many of them seem to have lost money on the

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[1] The jobbers state that they bought these goods of the Roberts Cotton Oil Co. of Jonesboro, Ark., for 41 percent goods and that they offered the Vermont dealer to make good the deficiency on presentation of claim.

Weeds growing from seed found in a molasses feed sold as a "dairy" feed. 129,000,000 weed seeds to a ton! Three for every square foot of a hundred acre farm! The soil was sterilized so that it is certain that every plant sprang from a weed seed from the feed.

Weeds growing from seed found in three different brands of molasses feeds! **From 20,000,000 to nearly 130,000,000 weed seeds to a ton! The soil was sterilized so that it is certain that every plant sprang from a weed seed from the feed.**

season's business. Local dealers, of course, were practically powerless, although many of them secured analyses of suspected cargoes in advance of sale and preferred claims for rebate. The dairymen, however, buying at a high price the lowered grade, doubtless got the worst end of the bargain. Inasmuch as the state law prescribes no standard for any class of goods, but permits the seller to fix his own standard—providing simply that whatever he selects he shall maintain—it would seem that the true onus lies at the doors of the jobbing trade as a whole. It knew fairly early in the season the untoward condition which confronted it, and should have lowered guaranties, for the time being, to meet the exceptional conditions. Some of the jobbers have discontinued the use of their special brands awaiting the reestablishment of normality in the trade. It may not be amiss to remark that even low grade cottonseed meal far below guaranty may be, and usually is, a better purchase at ruling prices for dairy feeding than are a multitude of speciously advertised goods of a less highly proteinous nature.

WEED SEEDS IN FEEDS

A large proportion of the samples were examined as to their weed seed contents. The by-products of the oil mills, the distilleries and the breweries, of the glucose and hominy works and of several flour mills passed muster; but a single oat feed, a guaranteed wheat (mixed) feed, and *every molasses feed* carried more or less weed seeds; and these were viable, able to germinate and flourish as only the green bay tree or a weed can do, save in one case[1] (Green Diamond) where the viability had seemingly been destroyed. The vigor of growth of these seeds is evident at a glance at the cuts opposite pages 4 and 5.

The results of the study of the weed seed situation appears below. Nos. 1 to 6 inclusive represent six molasses feeds (three samples of one brand), No. 7 is an oat feed and No. 8, a mixed (wheat) feed.

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[1] In one other case the seed failed to grow; but two other samples of the same brand carried large amounts of virile weed seed, hence it is not included in the omitted list.

	SEEDS	USEFUL SEED		NOXIOUS SEED	
	Percent	Numbers per pound of feed	Nature	Number per pound of feed	Nature
1*	4.	127,500,	mostly red top	9,500	(1-2 green foxtail, 1-5 wild turnip, 1-7 black mustard)
2	18.8	5,000,	1-2 timothy	64,500	(1-2 pigweed, 1-5 shepard's purse, 1-3 green foxtail, 1-16 witch grass)
3a*	1.	1,100,	3-5 "	3,000	(2-3 pigweed, 1-6 lady's thumb, 1-6 green foxtail)
b	2.3	2,900,	1-2 " 2-5 flax	5,900	(2-3 pigweed, 1-3 miscellaneous)
c	3.	5,000,	1-4 " 1-2 "	7,700	(2-5 pigweed, 1-5 green foxtail, 1-7 smartweed)
4	1.	200,	"	7,400	(1-3 pigweed, 1-3 shepard's purse, 1-6 foxtail)
5	7.6	3,400,	"	32,600	(2-5 pigweed, 1-2 green foxtail)
6	2.7	900,	1-2 " 1-2 oats	9,700	(1-3 pigweed, 2-7 green foxtail)
7	1.1	450,	1-2 " 1-2 oats	1,600	(3-7 kale, 4-7 miscellany)
8	0.9	225,	flax	1,150	(3-5 green foxtail, 2-5 wild buckwheat)

*Seeds did not grow; apparently treated to destroy viability.

The data in this table and the showing made in the photographs are suggestive. They tell the story better than words can tell it. The buyer of a ton of one brand of these molasses feeds purchased therein three weed seeds for every square foot of a hundred acre farm. 129,000,000 weed seeds to a ton! Bought and paid for by the farmer who wonders why he is pestered by so many weeds!

It is a matter of common knowledge that there are sold yearly hundreds of carloads of wheat screenings (which being interpreted means in the main weed seeds screened from wheat prior to the milling process). Sheep and poultry handle them well; but the digestive system of neither horse nor cow is able to destroy them. To employ materials carrying viable weed seed in the mixture of "dairy" or "horse" feeds, even though they are plastered over with molasses, is little short of atrocity.

Manufacturer or jobber	Brand	Guar.	Anal.	As to guaranty	No. insp's.
	COTTONSEED MEAL				
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41	41.3	Generally above,	15
F. W. Brodé Co., Memphis, Tenn.	Owl	41	38.9	Nearly always above,	14
F. W. Brodé Co., Memphis, Tenn.	Owl	41	39		
Hunter Bros. Milling Co., St. Louis, Mo.	Prime	41	40.5	More often above than below,	8
[1]Hunter Bros. Milling Co., St. Louis, Mo.	Prime	41	35.4		
J. Lindsay Wells & Co., Memphis, Tenn.	Star	41	39.5	More often above than below,	12
C. M. Cox Co., Chamb. Com., Boston, Mass.	Magnolia	41	36.9	As often above as below,	9
T. A. Bunch, Little Rock, Ark.	Old Gold	41	42.5		
W. P. Battle & Co., Memphis, Tenn.	Battle	38	39.5		
[2]Kaiser & Brown, Memphis, Tenn.	K. & B. Prime	41	20		
H. E. Bridges & Co., Memphis, Tenn.	———	41	37.5		
J. Lindsay Wells & Co., Memphis, Tenn.	Sun	41	43.4		
Chapin & Co., Boston, Mass.	Green Diamond	41	40.6		
D. L. Marshall & Co., Boston, Mass.	Phoenix	41	38.6		
	LINSEED MEAL				
American Linseed Co., Chicago, Ill.	Linseed Oil Meal	36	36.6	More often above than below,	13
American Linseed Co., New York, N. Y.	O. P. Oil Meal	32	35.5	Nearly always above,	13
Milwaukee Linseed Oil Works, Milwaukee.	Ground Linseed Cake	32	33.1	Generally below,	15
	GLUTEN FEED			Generally below,	15
Corn Products Mfg. Co., Chicago, Ill.	Buffalo	23	27.9	Generally below,	15
Glucose Sugar Refining Co., Chicago, Ill.	Buffalo	25	25.8	Always below,	7
Glucose Sugar Refining Co., Chicago, Ill.	Buffalo	24	25.6		
Warner Sugar Refining Co., Waukegan, Ill.	Warner	25	25.2		
Corn Products Mfg. Co., Chicago, Ill.	Warner	24	23.7		
J. E. Soper & Co., Boston, Mass.	Bay State	24	22.9		
Douglas & Co., Cedar Rapids, Iowa	Cedar Rapids	24	23.2	Always below,	4

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[1] See footnote, page 4.
[2] See text concerning this sample.

Manufacturer or jobber	Brand	Guar.	Anal.	As to guaranty	No. insp's.
DISTILLERS' DRIED GRAINS					
J. D. Page & Co., Syracuse, N. Y.	Empire State Dairy	32	30.9	Always below,	8
Clark Bros. & Co., ———	Empire State Dairy	30.22	30.7		
Chapin & Co., St. Louis, Mo	Ajax Flakes	33	30.9	Generally below,	9
Ajax Milling Co., New York, N. Y	Ajax Flakes	33	32.7		
Ajax Milling and Feed Co., New York, N. Y.	Ajax Flakes	33.5	35.5		
J. W. Biles Co., Cincinnati, Ohio	XX	30	29.5		
J. W. Biles Co., Cincinnati, Ohio	Union Grains	24	23.8	Generally below,	4
BREWERS' DRIED GRAINS					
Anhe'r Busch Brewing Co., St. Louis, Mo	Anheuser Busch	24	29.6		
Atlantic Export Co., Milwaukee, Wis	———	25	30.5		
W. J. Lemp Brewing Co., Milwaukee, Wis.	Holstein	27	28.1		
MOLASSES FEED					
American Milling Co., Chicago, Ill	Sucrene Dairy	16.5	18.9	More often below than above,	3
American Milling Co., Chicago, Ill	Sucrene Horse	13.5	19.	More often below than above,	4
American Cereal Co., Chicago, Ill	Molasses Dairy	16	15.8	Always above,	2
American Cereal Co., Chicago, Ill	Molasses Horse	11	15.0	Always above,	2
Chapin & Co., St. Louis, Mo	Green Diamond	16.5	14.8		
Prize Dairy Feed Co., Milwaukee, Wis	Prize Dairy Feed	18	18		
ALFALFA FEED					
Purina Mills, St. Louis, Mo	Pure Alfalfa Meal	16	13.	Always below,	2
HOMINY FEED					
C. M. Cox Co., Chamb. Com., Boston, Mass.	Wirthmore	10	10.3	Always above,	6
J. E. Soper & Co., Chamb. Com., Boston, Mass.	Blue Ribbon	11	10.9		
OAT FEED, CORN AND OAT FEED					
American Cereal Co., Chicago, Ill	Quaker Dairy	12	13.6	More often above than below,	15
American Cereal Co., Chicago, Ill	Schumaker Stock	11	10.1	More often below than above,	15
ANIMAL MEALS					
Bowker Co., Boston, Mass	Animal Meal	30	36.4		
J. W. Beech Co., Boston, Mass	Ground Beef Scraps	45	48		

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VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 132

JANUARY, 1908

Forest Planting in Vermont

BURLINGTON:
FREE PRESS PRINTING CO.,
1908.

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BULLETIN 132—FOREST PLANTING IN VERMONT

By L. R. Jones and C. R. Pettis

SUMMARY.

There are large areas in Vermont better adapted to forestry than to ordinary farm crops. The profitable course in the management of such lands is to encourage natural reforestation and to supplement by judicious planting. Pages 12-13.

The best kind of tree for general forest planting in Vermont is the white pine. Other conifers worthy of trial are Scotch pine, red pine, Norway spruce, European larch. The locust is of promise as a grower of posts. Pages 13-15.

The State Nursery can furnish this spring, seedlings of locust and white pine, and white pine seed. It will advise in securing further stock from commercial nurserymen as desired. Pages 15-18.

Advice is given as to kinds of soil suited for planting, as to time and method of planting, and as to transplanting native seedlings. Pages 18-21.

Forest trees may be started from seed. Sowing the seed in the field either broadcast or in spots is not advised. It is better practice to sow it in seed beds and to transplant the seedlings when strong enough. Pages 21-23.

The State laws are summarized relative to the appointment and duties of the State Forestry Commissioner, of town fire wardens, tax-exemption of planted lands, and the establishment and duties of the State Nursery. Pages 23-24.

INTRODUCTION

Bulletins 120, issued in March, 1906, "Planting White Pine in Vermont," and 127 in April, 1907, "State Nursery for Forest Tree Seedlings," are still available for distribution on request; hence no attempt will be made in the present bulletin to discuss in detail the facts there set forth. The aim of this bulletin is rather to answer briefly the following specific questions:

1. What is the present outlook as to forest planting?
2. What are the best kinds of trees to plant?
3. What can be secured from or through the State Nursery in the spring of 1908?
4. How is forest planting best done?
5. How can forest seedlings be grown at home?
6. What are the state laws relative to tax exemption and other forestry matters?

WHAT IS THE PRESENT OUTLOOK AS TO FOREST PLANTING?

This question is clearly formulating itself in the minds of many Vermonters. An attempt to contribute to the right answer has been made in some detail in bulletins 120 and 127. Assistance has also been had in the formulation of a correct policy in forestry management from the addresses of experts at the annual meetings of the Vermont Forestry Association, and in the publications of the Forestry Commissioner. In the light of the experience of the past year the following statements are made with fuller confidence. There are thousands upon thousands of acres in Vermont which will prove more profitable for forestry than for ordinary farming. Timber lands if rightly managed will probably in the end bring a larger return on the investment than any other farm property. Nature if left to herself will clothe many of Vermont's waste lands with trees. Man should simply aim in forestry management to cooperate with nature, so directing her processes as to secure natural reforestation with valuable species so far as practicable, and supplementing this by planting where opportunity favors.

It was to economize and aid this movement that the State Nursery was established by the legislature of 1906. It is required by law to supply forest tree seedlings for planting within Vermont, so far as practicable and at the approximate cost of production. Hence last spring it offered white pine and locust seedlings of varying sizes and prices. The demand far exceeded the available supply. The details relative to this distribution will appear in the forthcoming annual report. Suffice it to say here that every shipment was reported to have arrived in good condition. The locusts were one year old seedlings, practically all of which lived and made rapid growth; and there is no reason to doubt that they will continue to prosper. Most of the white pine were two year old seedlings. Three-fourths of the buyers report a loss of less than five percent and some lost less than one percent. In the few cases where there was large loss there were evident reasons for it, such as excessive application of strong commercial fertilizer or the drying out of the seedlings by protracted drought before they had established new roots. In no single case was failure reported, which is surprising as well as gratifying considering the newness of the undertaking and the lack of experience in such planting by practically all concerned. It seems reasonable to anticipate results fully as satisfactory during the coming spring. Most cases of considerable loss were caused by dry, hot weather parching the plants in June and July; hence it is urged that the plants be secured and set a little earlier than was done last year.

KINDS OF TREES TO PLANT IN VERMONT.

The *white pine,* either in pure plantation or mixed with hard woods such as the hard maple and white ash, is *the most promising tree for general planting* in Vermont. Its value has been demonstrated beyond question and it may safely be used on any scale desired, large or small, if soil conditions are suitable. Of the other coniferous trees, the *red pine, Scotch pine, Norway spruce, European larch,* and *"white cedar"* (arbor vitae) deserve attention. The peculiar value of the *locust* for growing fence posts is discussed at the foot of this page. These will be offered by the State Nursery as soon and as far as practicable, and it is hoped trial will be made of them. In general, trial of kinds other than the white pine should, however, be made on a relatively small scale. The white pine seems suited to a wide range of Vermont soils. It will grow well on the leanest and rockiest of worn-out pastures, and on any land where spruce and maple will thrive. It is not suited to low wet land. The Scotch and red pines may be planted anywhere that the white pine will grow. They differ from the latter in that they make a somewhat faster growth for the first few years, especially if on very light soil. If one wishes to secure the quickest covering of such soil with valuable trees the Scotch pine is to be recommended, though it is doubtful whether the matured crop will be as valuable for lumber as the white pine. The red pine is a native tree, often called Norway pine, found growing at its best on rather dry gravelly loam and for such soil is quite as valuable a timber tree as the white pine. The Norway spruce is preferable to our native spruces and is adapted to similar soils, i. e., cool and fairly strong gravelly or clay loam. The same may be said of the European larch in comparison with our native larch. That is to say, if a man wishes to try larch or tamarack he should choose the European larch, which will probably grow well on any good soil of fair moisture, but is not adapted to dry sandy soil. No adequate trial in the planting of our native white cedar or arbor vitae has as yet been made. Where attempted, therefore, it should be in an experimental way and only on such soils as are known to favor it in the natural state. The common locust has a peculiar value. As explained in previous publications it is the most promising tree to plant for growing stakes and fence posts. It can be secured so quickly and cheaply from the seed that a trial plantation costs but little. It will grow in any soil that is not wet and is especially suited to waste ridges. The trees will reach a size suitable for posts in from 12 to 25 years, and when cut reproduce themselves by sprouting from the root. The only serious question is as to possible damage from an insect, the locust borer. A small plantation of locusts to furnish posts is therefore well worthy of trial by anyone attempting forestry planting.

SEEDLINGS, ETC., FOR SALE[1]

The State Nursery, in compliance with the law, offers the following forest tree seedlings for sale in the spring of 1908, and will list orders as received so long as the supply lasts. These offerings are restricted according to law for use in plantations to be made in this State. Since the supply of white pine ready for distribution from the State Nursery this spring is quite limited, it seems fairer to all parties to restrict the size of orders in the way outlined below. In all cases the prices quoted cover cost of packing but not of carriage. The goods will be forwarded with express charges to be collected on delivery unless other arrangements are made. For convenience the prices are quoted by the 1,000, but orders for any smaller amount will be filled at the same rate.

Persons desiring to secure any seeds or seedlings, either from the following lots, or from commercial nurserymen with our advice, should write as soon as convenient, indicating their plans and asking for order blanks. Cash should not be sent with such requests. *Address all such requests to State Nursery, Experiment Station, Burlington, Vt.*

Lot 1. White pine, nursery grown, three years old, transplanted in spring 1907, size four to six inches. This stock is in excellent condition for setting in permanent forest plantation this spring. Price per 1,000, $10. *No order for over 1,000 to be sent to one person will be accepted before April 1.* If stock is not all engaged for such small orders by that date, larger orders will then be filled.

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[1] If the following lists are compared with those of last year, (bulletin 127) it will be seen that the offerings of white pine are limited to higher priced stock. Pine seedlings must be at least two years old before they can safely be taken from the seed bed for distribution or planting. The two-year old seedlings offered at a low figure last year were received through the courtesy of the New York State Nursery. Since none will be available from that source this year no more such low priced stock can be offered by the State Nursery until 1909. Presumably some of the seedlings started in 1907 can be distributed advantageously then and the aim will be to have others following in sequence each year thereafter.

Lot 2. White pine, nursery grown, four years old, transplanted in spring of 1906, size five to seven inches. This stock is a little larger and has stronger root growth than lot one, since it has stood two years in the nursery row since transplanting. It is in excellent condition for permanent forest plantation. Price per 1,000, $12. *Same restriction as lot one as to size of order* and the same restriction will hold for any order including lots one and two in combination, i. e., not over 1,000 total of these two kinds will be booked for one address before April 1.

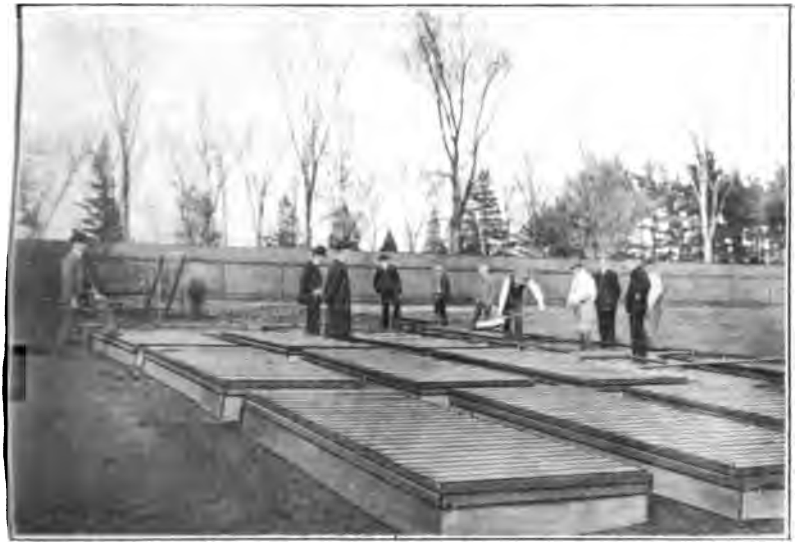
Lot 3. White pine, nursery grown, five years old, transplanted twice, size 10 to 12 inches, vigorous plants with strong roots suitable for planting where conditions are less favorable or where immediate results are desired. Price per 100, $2. *Not over 100 of these plants will be booked for any one party until after April 1.* Thereafter larger orders will be filled if the supply is not exhausted.

Lot 4. Common or black locust, one-year-old seedlings, two to three feet high, suitable for immediate use this spring in permanent plantations. Price per 1,000, $2.50.

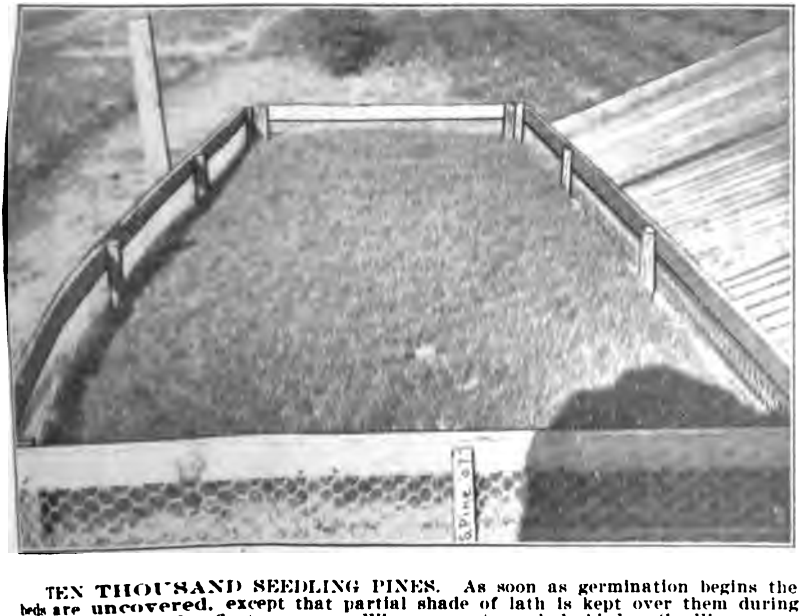
White pine seed. Native seed, collected in this vicinity in the autumn of 1907, sent by mail postpaid at the following prices:

One ounce	15 cents
Four ounces	50 cents
In lots of ten ounces or more to one party	10 cents per ounce

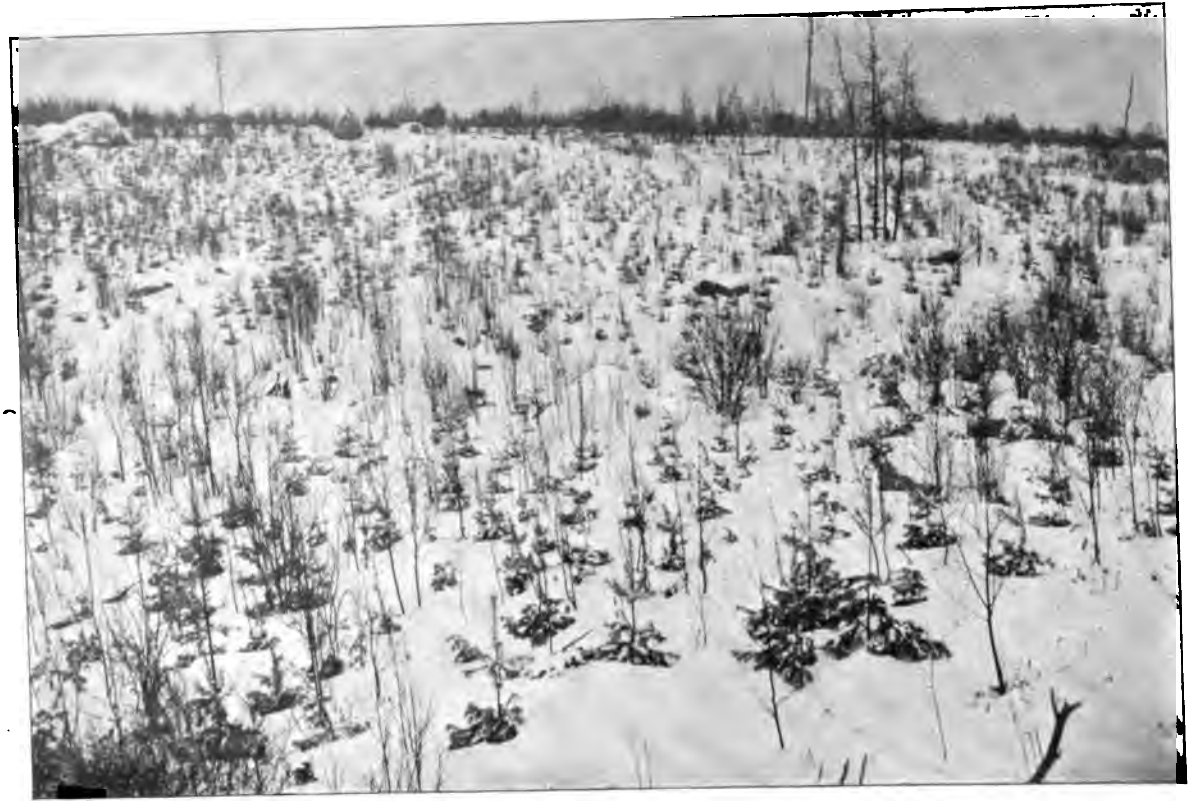
One ounce of seed properly handled should produce 1,000 or more seedlings. Ten ounces is sufficient to sow broadcast a bed 4 by 12 feet; or for a much larger area if put in drills. There is probably a sufficient supply at the State Nursery to meet all legitimate requests, but the right is reserved to decline large orders from our stock if necessary to fill larger numbers of small



VERMONT STATE NURSERY. Making and sowing the seed beds, May, 1907. Each bed 4x12 ft.: surface slightly raised, seed broadcasted and a light covering of soil sifted over it. Beds in foreground completed: closely covered with building paper at sides and lath above until germination begins.



TEN THOUSAND SEEDLING PINES. As soon as germination begins the beds are uncovered, except that partial shade of lath is kept over them during bright weather the first summer. Wire screen to exclude birds. Seedlings must remain in the bed two years.



WHITE PINE PLANTATION. Waste land: natural growth of bird cherry and poplar underplanted with white pine. New York State land, Adirondack region. (This cut and the next two loaned

SCOTCH PINE PLANTATION. Burned over land, planted in 1902, photographed in 1906. The Scotch pine makes a faster growth than the white pine for a few years, but the white pine will overtake it in the end. New State land, Adirondack region.

Underplanting white birch with evergreen seedlings. On New York State lands near Saranac Lake. New York now owns 1,518,450 acres of state forest land, largely in the Adirondacks, and is this year contemplating the purchase of 1,000,000 acres more.

ones. In such cases aid will be afforded in securing such further seed as is desired from outside sources. (See general directions as to seed planting on page 21. Detailed direction will be sent to each purchaser of seed).

Native pine seedlings. The management of the State Nursery last spring collected and sold native white pine seedlings, three to four years old, size four to eight inches, for $3.00 per 1,000. The available supply near the nursery is so nearly exhausted that it cannot promise to collect many, if, indeed, it can any in 1908. It will, however, receive and enter requests for such and arrange to have these filled if found practicable. In this the nursery management will, however, merely act as agent to put collector and purchaser into communication. To this end it will be glad to learn the address of parties who can collect such native pine seedlings and the price at which they can be offered for sale. If any persons are found who care to undertake this work, such requests will be referred to them as received. As explained later (see page 21), nursery grown stock is generally better than native seedlings.

ASSISTANCE IN PLACING ORDERS WITH COMMERCIAL NURSERYMEN

The orders last spring exceeded the stock then available for distribution and the correspondence to date indicates a like condition for 1908. Arrangements are therefore contemplated by which such orders for stock of other kinds of seed or seedlings, or larger amounts than the State Nursery can supply, may readily be referred to commercial nurserymen. Prices on such goods will vary somewhat, according to the size of the order. It is not practicable to quote the exact prices further than to say that for white pine they will range from in the neighborhood of $4 per thousand for two-year-old seedlings (not transplanted) to $30 per thousand for the larger transplants. The trade catalogues will doubtless be issued before this bulletin is received by its readers and detailed advice will be furnished upon request thereafter. In this connection the State Nursery management will give those inquiring the benefit of its judgment as to the selection of stock and as to relative values offered. It will then put the prospective purchaser into direct communication with the commercial nurseryman. Further than this it can assume no responsibility.

ADVICE TO BUYERS AS TO CHOICE OF STOCK

Locusts. The State Nursery can probably meet all the requests made for locust seedlings—see lot 4—and the price of these is doubtless as low as plants of this size can be handled at any time in the future. Any one who desires to make a plantation of locusts may therefore well secure this stock.

White pine. The white pine seed is this year of excellent quality and low price. The pine seeds abundantly only once in three or four years, and 1907 was a good seed year. Those who wish to try planting seed will therefore have a better opportunity this spring (1908) than is likely to occur again for two or three years.

As already explained, none of the small seedlings (two years old) such as were offered last year, and will be next, are available at the State Nursery. If those are desired they must be secured from commercial nurserymen. All the stock listed was transplanted either one or two years ago and is, therefore, well suited for planting at once in permanent plantation.

ADVICE RELATIVE TO PLANTING TREES

A special circular containing concise and practical planting directions, prepared with the approval of the State Forestry Commissioner, will be sent to each purchaser. All that will be given here aims to help one in deciding as to the preliminary plans and the placing of the order.

WHERE TO PLANT

The most promising situations for forestry plantation in Vermont are where one can supplement the natural processes of reforestation, such as:

1. Recently cut-over woodland where the prospects are that imperfect tree covering would develop or where it would be of an inferior kind of trees.

2. Vacant spots in land naturally growing up to spruce or other valuable forest trees.

3. Old pastures now of low value because of weediness or inaccessibility.

4. Sandy or gravelly wastes, too barren for agricultural uses.

5. Steep hillsides where the soil is liable to wash badly.

Personal advice to individual planters will be given without charge so far as this can be done by correspondence. Where it seems desirable to have a personal visit from the consulting forester or other expert this will be arranged when practicable by the State Forestry Commissioner, providing the person requesting it will pay the travelling expenses.

Requests for such personal visits or for personal assistance in planting should be addressed to Arthur M. Vaughan, State Forestry Commissioner, Randolph, Vermont. In most cases the planter who has not had previous experience should be content the first year to make a small trial plantation unless he thus secures the advice of an experienced forester. He can hope to profit by his own experience and push the work more rapidly in subsequent years as dictated thereby.

TIME AND METHOD OF PLANTING

Season. Early spring is the best season for forest tree planting in Vermont. The work may begin as early as the ground can be worked and may with evergreens (pine, spruce, etc.) be continued as late as the middle of May or even the latter part of May. The earlier planting is safer however and is especially to be urged on dry soils which may suffer in early summer drought.

Distance. For general forest plantations a distance of 6 x 6 feet is recommended. This requires 1,210 trees per acre. Some advocate 5 x 5 feet (1,740 per acre) but the writers' experience favors the wider spacing. Others say that 7 x 7 (890 per acre) or even 8 x 8 feet apart (680 per acre) is close enough, and there are excellent plantations on the Billings farm at Woodstock where the trees are even farther apart. Where there is a natural sprout growth coming in to occupy part of the space and thus to help cover the soil, the artificially planted trees may be proportionately more remote. If for example white pine is destined to be the ultimate crop it is just as well to have one-half the stand of maple or similar trees which will serve as "fillers" for the first twenty years and so force the pines into taller, clearer growth. In such case a stand of pines 8 x 8 feet, or less than 700 to the acre, will certainly suffice.

Method. The roots of such seedlings as are recommended are small and the planting is a simple matter. It is best done by two men, one opening the holes with a grub hoe or spade, the other setting the plants by hand. Two men should set from eight hundred to fifteen hundred trees per day according to soil conditions.

Transplanting native seedlings. This is of course satisfactory and practicable for deciduous, or broad leaved trees, such as maple. It can also be done with good results in the case of the conifers or evergreens, such as pine, spruce, etc., where the seedlings are abundant. The only tree with which the writers have had much personal experience or about which they can learn from that of others in forest practice in Vermont is the white pine. It is possible in the spring to transplant young pine of any reasonable size. The pine seedling must be two years old before it is safely moved. Thereafter both the amount of work and the danger of loss increases rapidly with the size of the tree. The ideal age for transplanting pine is three to five years, when the seedlings are three to eight inches tall. Most people seem instinctively to seek larger trees but the smaller ones are preferable. Where such little native seedlings are abundant especially if in moist sandy loam apart from other growth, they may be collected cheaply and, if done in early spring and pains are taken to secure the roots unmutilated, they survive transplantation well. The roots come up best soon after the frost leaves the ground. Nursery grown plants are of course preferable as having a better root system and having received no check in their development, but unless these can be secured at a low price the use of native transplants is commended to such as can secure them cheaply and in abundance.

STARTING TREES FROM THE SEED

It is practicable for anyone, providing he cares to learn the methods and has time and an aptitude, to grow the seedlings of any of these forest trees direct from the seed. Two methods of seed sowing in the field have been advocated and tried more or less, namely, broadcasting and spot planting.

Broadcast sowing and spot planting. Broadcast sowing of the seed without previous preparation of the soil has often been tried with various kinds of trees, but rarely has it proved successful. The "spot planting" method entails opening or stirring up the soil in spots so as to make suitable seed beds at desired distances and planting from two to several seeds in each spot in the hope that at least one will survive. This has been proved practicable for some of the nut bearing and other broad-leaved or deciduous trees whose seedlings make vigorous growth during the first year or two. Locusts have been established in this way. Spot planting is preferable in general to broadcasting the seed, but both methods alike have as a rule been followed by disappointment and partial or complete failure, even with the stronger growing deciduous trees. White pine and other coniferous trees produce seedlings so weak and so slow of growth for several years that there is even less to encourage one to attempt field sowing of the seed. The large amount of expensive seed required is usually enough to render it impracticable. When to this is added the loss from birds and animals eating the seed, the irregularities in germination and the loss from the overcrowding of the weakling seedlings by more vigorous neighboring plants, the chances of a satisfactory outcome will usually be reduced to the vanishing point. In brief then, all having practical experience agree that the economical plan, at least with the smaller seeded coniferous trees, is to start the seedlings in garden beds and, later, to transplant them.

Seed beds. Believing that some at least of those who contemplate forestry planting will find it a matter of satisfaction and economy to grow their own seedlings the following general suggestions are given as to making and caring for such seed beds. Further and more detailed directions will be sent to anyone purchasing seeds. Home growing of tree seedlings in garden beds or rows is practicable. It requires an understanding of the methods suited to each kind, coupled usually with some practical experience, to insure full success. Locusts and other deciduous trees make strong growth from the start and so present relatively little difficulty. They can be planted in drills, and may be transplanted to the field when one year old.

Coniferous seeds such as pine, spruce, etc., need more care and the seedlings must remain in the seed bed two years before they are large and strong enough to be transplanted. The bed must be on well drained soil, preferably a sandy loam, free from weed seeds, in good tilth and carefully prepared. The seed may be drilled but is better broadcasted. In the latter case eight to twelve ounces of seed should be sown on a bed four by twelve feet. This seed should then be lightly covered with soil and the whole protected by a layer of leaves, straw or other litter or a close shade to hold moisture until germination begins. This requires two weeks or more according to temperature conditions. Partial shade must be kept over the seedlings during the first summer, either by brush or lath screens. If sparrows or other birds are numerous a netting to keep them away is also desirable. A protective covering of leaves or something similar is needed the first winter. Thereafter they require no unusual attention. The chief cause of failure is damping-off, a fungous disease which attacks the stems of the seedlings during the month immediately following their germination. Sprinkling the surface of the bed with hot sand is a partial preventive but the chief reliance must consist in keeping the surface of the beds as dry as practicable during this critical period. It is evident from what has been said that until one has had experience he should proceed on only a small scale in such nursery-bed work.

By attention to the more specific and detailed directions to be sent with the seed one may safely make such a trial of seed beds. Since white pine seed available this spring is of exceptionally good quality and low price it is believed that a considerable amount of it may wisely be used in this way.

LAWS AND REGULATIONS OF INTEREST TO TREE PLANTERS

The full text of the state laws and regulations relative to forestry is soon to be published as a special bulletin by the State Forestry Commissioner. This may be secured upon request addressed to Arthur M. Vaughan, Randolph, Vt. A brief summary of three matters of chief concern follows:

1. *The appointment and duty of the State Forestry Commissioner.* One member of the State Board of Agriculture is so designated by the Governor. His chief duties are to administer the fire laws, to formulate and administer regulations governing tax exemption for planted lands, and to issue forestry publications. The first selectman of each town is forest-fire warden; and the Forestry Commissioner may appoint fire-wardens for unorganized towns or gores. The duties of the Forestry Commissioner and fire-wardens relative to extinguishing forest fires are clearly defined, as is the liability of persons setting such fires. The Forestry Commissioner advises relative to forestry plantation, publishes bulletins concerning forestry matters, and formulates and administers regulations relative to tax exemption of planted lands.

2. *Regulations relative to tax exemption of land planted to forest trees.* All forest or waste lands replanted to trees in the manner prescribed by the State Forestry Commissioner may be exempt from taxation for a term of ten years thereafter. According to the rules recently promulgated such planted trees shall be

set as close as eight by eight feet and comprise a total of at least six hundred per acre. Such land must be maintained in good condition, must not be pastured, and must carry at least five hundred living planted trees per acre at the end of five years. The commissioner prescribes the species and the season of planting.

3. *The establishment and purpose of the State Nursery.* The sum of five hundred dollars annually for five years (1907-1911) is to be paid to the Experiment Station to be used in establishing and maintaining a State Nursery for the propagation of forest tree seedlings. These are to be furnished as far as practicable to owners of Vermont lands for forest planting in this State at as near as can be computed the actual cost of production.

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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 133

JANUARY, 1908

Commercial Feeding Stuffs

BURLINGTON:
FREE PRESS PRINTING CO.,
1908.

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☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 133.—COMMERCIAL FEEDING STUFFS

By J. L. Hills. C. H. Jones and C. Cutler

One hundred and eighty-five samples of commercial feeding stuffs were drawn in the winter inspection of 1907-08. Roughly half of these represented 50 brands of guarantied goods (by-products of the oil mills, glucose and breakfast food factories, the distilleries and breweries, and manufactured products), and half were unguarantied feeds (wheat offals and home grown provenders). These samples were tested for protein only, for reasons hitherto explained.

RESULTS OF INSPECTION

The results of inspection of the guarantied goods are displayed on pages 30-32. These tables show the manufacturer's name, brand name, protein guaranty and analysis of each goods, a statement of the number of inspections since 1899 in which each brand has been analyzed and the number of times it has and has not met the protein guaranty statement within one percent.

A few remarks touching the tabulated results seem in order.

Ten *cottonseed meals* were sampled, all of which made good their protein guaranties, a very different condition of affairs from that which obtained last year.

Four *linseed meals* were analyzed. Two old process meals (American, Metzger) were well above guaranty; one new process (American) and one old process (Kelloggs & Miller) each fell about 1½ percent below guaranty.

Nine brands of *gluten feeds* were found. Six (Buffalo, Warner, Cream, Pekin, Hunter Bros.) met guaranty; one (Cedar Rapids) was more than one percent short; two (Clinton and Bay State) proved respectively to be 4 and 5 percent below guaranty.

Six brands of *distillers' grains* were tested, two of which (Empire State and XXXX) met guaranty, and four of which (Empire State, XXXX, Ajax Flakes, Climax Grains) failed to meet guaranty by amounts ranging from 1½ to 4 percent.

Union Grains, a proprietary mixture offered by a distillers' grains house, into which these goods largely enter, was found to run a percent below guaranty.

Five brands of *brewers' dried grains* were tested. Four met guaranties; one lot (W. J. Lemp Brewing Co.) was unguarantied.

Five samples of *oat feeds* were taken. Three of these (Schumaker's Stock, Boss Chop and Taylor's Stock) met guaranties; and two (Vim and Sterling) practically met them being but a fraction of a percent low.

Eight brands of *molasses feeds* were found. Four (Molac Dairy, Molac Horse, Sucrene Dairy) met guaranties; two (Sucrene Horse, Hammond's Dairy) were so slightly below as to practically meet guaranty; Molasses Grains were 1 percent below promise and the Daisy Dairy and Prize Dairy feeds, respectively 2 and 5 percent below guaranties. It was noted in the last feeding stuffs bulletin (No. 131) that "every molasses feed carried more or less weed seeds." Pictures were given of weeds growing from seed found in molasses feeds. These goods were similarly tested in the present inspection. The Daisy Dairy and Molasses Grains feeds were found comparatively free from weed seeds, and such as were present did not grow. The others contained living weed seeds as indicated on the opposite page.

Three brands of *flax feeds* were found. These goods are new in New England markets. Examination shows them as a whole to be composed of broken flaxseed, straw and many seeds and screenings, some samples being very clean and others quite the reverse. They are particularly characterized, however, by very large amounts of weed seeds which are capable of germination. Two samples of the H. J. Flax Feed contained respectively 11.9 and 14.3 percent of weed seeds; the Northern Cereal Co.'s Flax Feed, 6.5 percent, and C. R. Lull's Ground Flax Flakes, 20.4 percent. (See table on opposite page as to weed seeds).

The Ground Flax Flakes met guaranty and the N. C. Co.'s nearly met it; but the H. J. goods ran 4 percent below.

Four *alfalfa products* were analyzed. One (Purina Feed Mash) met guaranty; two others (Cypher's Mealed Alfalfa, Purina Alfalfa Meal) nearly met guaranty; while another (Ralston Purina Alfalfa Meal) failed by nearly 3 percent.

Wirthmore Dairy Feed and Husted's Forcing Mash—proprietary articles—failed to meet guaranty by 1.3 and 2.3 percents respectively.

Twenty-two brans, fourteen middlings, twenty-two mixed feeds and four Red Dog flours, appeared to be of standard grade, although one winter wheat bran, contained an inordinate amount of wheat screenings.

Thirty provenders—local grindings—seemed to be of good grade.

WEED SEEDS IN MOLASSES AND FLAX FEEDS

Brand.	Percent.		No. per lb. (calculated)		Nature of seed.	
	Useful.	Harmful.	Useful.	Harmful.	Useful.	Harmful.¶
MOLASSES FEEDS.						
Sucrene Dairy†† ..	0.5	6.	2,500	48,750	*	Pigweed, green foxtail, tumbling mustard.
Sucrene Horse†† ..	2.6	6.7	4,750	45,150	*	Pigweed, green foxtail, tumbling mustard.
Molac Dairy	0.1	3.2	2,700	7,050	*	Pigweed, green foxtail, lady's thumb.
Molac Horse	1.8	2.1	1,800	9,050	†	Pigweed, green foxtail, lady's thumb.
Hammond Dairy ..	0.2	5.2	1,350	29,250	*	Pigweed, green foxtail.
Prize Dairy	2.5	1.6	700	5,900	‡	Pigweed, green foxtail, lady's thumb, and wild buckwheat.
FLAX FEEDS.						
H. J. Flax Feed...	0.2	14.2	2,500	82,350	*	Pigweed, green foxtail.
H. J. Flax Feed...	3.0	11.9	3,200	95,950	§	Pigweed, green foxtail, tumbling mustard.
N. C. Co. Flax Feed,	—	6.5	——	43,750		Pigweed, green foxtail.
Lull's ground flax flakes	0.3	20.4	2,700	131,100	*	Pigweed, green foxtail, tumbling mustard, lady's thumb, poas, amaranths, kale, catchfly.

*Timothy. †Timothy and oats. ‡Timothy, oats and wheat. §Timothy, wheat and flax. ¶Principal ones only cited; one lot had 17 sorts of weeds, another, 18.

††The Boston representative of the American Milling Co. assures the writer that measures are to be taken in the immediate future which will serve to eliminate weed seeds from Sucrene feeds.

This table is commended to the careful scrutiny of feed buyers. In every case more or less of these seeds grew when tested for germination. More or less of such seed doubtless passes through a cow or horse undigested and is voided in the manure, its vitality and power for harm unimpaired.

One of the flax feed jobbers states that he has sold 5,000 tons in New England. It would be a good problem in arithmetic in a rural school for the teacher to set the scholars at work calculating the numbers of weed seeds thus imported from western grain fields to seed down New England meadows. Another jobber writes that there are certain weed seeds present but that they are good food for cows—which may be true—and that "of course they are all ground." Unfortunately his assurance, as well as that given by the name of the goods, is not borne out in fact, as more than a fifth of the entire bulk of the sample, equivalent to over 400 pounds to a ton, consisted of unground weed seeds, from which, when germinated, sturdy growth arose. Seventeen different sorts of weed seeds were identified in this sample.

Manufacturer or Jobber.	Brand.	Protein.		*No. of inspect'n.		
		Guar.	Anal.	Total.	Above guar.	Below guar.
COTTONSEED MEAL						
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41	44.3	16	14	2
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	38	38.4			
F. W. Brodé Co., Memphis, Tenn.	Owl	41	42.1	15	14	1
J. Lindsey Wells Co., Memphis, Tenn.	Star	41	44.3	13	11	2
Hunter Bros. Mill Co., St. Louis, Mo.	Prime	41	41.2	9	6	3
American Cotton Oil Co., New York, N. Y.	Choice	41	42.5	15	14	1
Chapin & Co., Boston, Mass.	Gr'n Diamond	41	40.5	9	8	1
H. E. Bridges & Co., Memphis, Tenn.		41	45.6	2	1	1
S. P. Davis, Little Rock, Ark.	Good Luck	38	44.9			
Roberts Cotton Oil Co., Jonesboro, Ark.	Choice	41	43.4			

*See second paragraph, page 27.

Manufacturer or Jobber.	Brand.	Protein. Guar.	Protein. Anal.	*No. of inspect'n. Total.	*No. of inspect'n. Above guar.	*No. of inspect'n. Below guar.
LINSEED MEAL						
American Linseed Oil Co., Chicago, Ill.	New process	36	34.6	14	10	4
American Linseed Oil Co., Chicago, Ill.	Old process	32	35.9	14	12	2
Metzger Seed and Oil Co., Toledo, Ohio	Old process	30	35.9	8	7	1
Kellogg & Miller Co., Amsterdam, N. Y.		36.7	35			
GLUTEN FEED						
Glucose Sugar Refining Co., Chicago, Ill.	Buffalo	23	24.1	16	9	7
Glucose Sugar Refining Co., Chicago, Ill.	Buffalo	25	26.1			
Corn Products Mfg. Co., Chicago, Ill.	Buffalo	—	23.7			
Clinton Sugar Refining Co., Clinton, Iowa	Clinton	24	19.7			
Corn Products Refining Co., New York, N. Y.	Warner	24	25	8	4	4
Corn Products Refining Co., New York, N. Y.	Cream	20	22.6			
J. E. Soper & Co., Boston, Mass.	Bay State	24	18.8	2	0	2
Glucose Sugar Refining Co., Chicago, Ill.	Pekin	24	27.2	8	3	5
Corn Products Refining Co., New York, N. Y.		24	25.9			
Douglass & Co., Cedar Rapids, Iowa	Cedar Rapids	24	22.7	5	2	3
DISTILLERS' DRIED GRAINS						
Ajax Milling Co., Buffalo, N. Y.	Ajax Flakes	33	30.1	10	3	7
J. D. Page & Co., Agts., Syracuse, N. Y.	Em. St'e Dairy	33.2	29.6	9	2	7
N. Y.						
J. D. Page & Co., Agts., Syracuse,	Em. St'e Dairy	32	32.3			
Deutsch & Sickert Co., Milwaukee, Wis.	Climax Grains	34	32.4	2	0	2
J. W. Biles Co., Cincinnati, Ohio	XXXX	33	30.7	6	2	4
J. W. Biles Co., Cincinnati, Ohio	XXXX	32	32.9			
J. W. Biles Co., Cincinnati, Ohio	Union Grains	24	23	5	5	0

*See second paragraph, page 27.

Manufacturer or Jobber.	Brand.	Protein.		*No. of inspect'n.		
		Guar.	Anal.	Total.	Above guar.	Below guar.
BREWERS' DRIED GRAINS						
Atlantic Export Co., Milwaukee, Wis.		25	27.6	2	2	0
Atlantic Export Co., Milwaukee, Wis.		27	31.8			
Anheuser Busch Brewing Co., St. Louis, Mo.		24	24.7	3	3	0
Jos. Schlitz Brewing Co., Milwaukee, Wis.		24.5	27.3			
W. J. Lemp Brewing Co., St. Louis, Mo.		—	30.8			
FLAX FEED						
Henry Jennings, Boston, Mass.	H. J.	17.34	13.7			
C. R. Lull, Milwaukee, Wis.	Ground flax flakes	17.34	17.3			
Northern Cereal Co., Duluth, Minn.	N. C. Co.	15.34	14.9			
MOLASSES FEED						
American Milling Co., Chicago, Ill.	Sucrene Da'y	16.5	17.1	6	6	0
American Milling Co., Chicago, Ill.	Sucrene H'r'e	13.5	13	5	4	1
Quaker Oat Co., Chicago, Ill.	Molac Dairy	16	16.	4	4	0
Quaker Oat Co., Chicago, Ill.	Molac Horse	11	11.1	3	3	0
Milwaukee Molasses Feed Co., Milwaukee, Wis.	Prize Dairy	17	11.7	2	1	1
Frances Duhne, Jr., Milwaukee, Wis.	Molas. grains	15	13.9			
Western Grain & Product Co., Hammond, Ind.	Hammond Da'y	17	16.4	3	2	1
Great Western Cereal Co., Chicago, Ill.	Daisy Dairy	16	13.8			
OAT FEED						
Quaker Oat Co., Chicago, Ill.	Schumaker	10	11.6	16	12	4
Quaker Oat Co., Chicago, Ill.	Vim	7.5	6.8	13	11	2
Great Western Cereal Co., Chicago, Ill.	Sterling	11	10.1			
Great Western Cereal Co., Chicago, Ill.	Boss Chop	8	9.4	7	7	0
ALFALFA MEAL						
Cyphers Incubator Co., Buffalo, N. Y.	Mealed	17.4	17			
Purina Milling Co., St. Louis, Mo.	Purina	16	15.4	3	1	2
Purina Milling Co., St. Louis, Mo.	Purina mill feed mash	17	17.3			
Ralston Purina Mills, St. Louis, Mo.		16	13.1			
MISCELLANY						
Husted Milling Co., Buffalo, N. Y.	Dairy Feed		21.1			
St. Albans Grain Co., St. Albans, Vt.	Wirth'e Dairy	24	22.8			

*See second paragraph, page 27.

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

UNIV. OF MICH.
MAY 21 1908

VERMONT AGRICULTURAL
EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 134

MARCH, 1908

Commercial Fertilizers

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Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

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BULLETIN 135; COMMERCIAL FERTILIZERS

A QUARTER CENTURY OF FERTILIZER INSPECTION SOIL DETERIORATION AND SOIL HUMUS

By J. L. HILLS, C. H. JONES and C. CUTLER

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SUMMARY

III. Results of inspection. The Station has drawn from dealers' stocks and analyzed 130 of the 131 licensed brands, the output of 11 companies, all this year's goods.

1. Quantity of plant food. Seventy-two per cent of the brands met their guaranties. Six brands failed to afford a commercial equivalent of their promises. One brand was deficient in all three ingredients and more than 10 percent short of its commercial value as guarantied. A formal complaint of this case has been made to the State's Attorney of Washington County. Pages 71-79.

2. Quality of plant food. The quality of the crude stock used in manufacturing the goods on the whole seemed all that could be wished. A few criticisms, however, may be made. Two-fifths of the brands, mostly the lower grades and lower priced goods, carried no water-soluble nitrogen. An inferential claim, that sulphate of potash was used, is made for three-fifths of the brands; only three brands contain any appreciable quantities of sulphate. The organic nitrogen used, with one exception, seems to have been of good quality.—Pages 79-83.

IV. Selling prices and valuations. The average selling price was $31.24; the average valuation, $20.75. One dollar in three spent for mixed fertilizers was paid to the manufacturer, railroad, and selling agent for their work, while only two of the three paid for plant food. But 58 cents' worth of plant food was bought for a dollar in average low grade goods, and 67 cents' worth in medium grade goods. The average high grade brand, however, afforded 73 cents' worth for a dollar. Some Vermont buyers paid nearly twice as much for plant food as did others.—Pages 83-91.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 92-105.

VI. A comparison of analyses of brands for five years shows in some cases essential evenness and in others consid-

erable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.—Pages 106-114.

VII. A survey of 25 years of fertilizer inspection in Vermont is presented on pages 115-141, and specially summarized at the close of that article on pages 140-141.

VIII. A discussion of soil deterioration and soil humus may be found on pages 142-177. This attempts to cover causes and remedies, with particular reference to the humus content of the soil, its benefits, maintenance and increase. This article is specially summarized on page 176.

IX. The bulletin is thoroughly indexed on pages 178-181.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletins of the Station dealing with commercial fertilizers shall not only give the results of the analyses of these goods, but shall also publish "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." Two bulletins are issued each spring, in April and in June. The first gives the analyses of about 60 brands, the valuation schedule, a discussion of its use, a table of analyses for five years, etc. The second discloses the analyses of all the brands collected, shows their composition during the past five years, contains a general review of the trade of the State, makes statements as to the quantity and quality of the plant food sold in the sundry brands, considers the comparative values of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.

These general matters are annually reviewed. In addition thereto, in the second and larger bulletin there is yearly presented a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99 and 130. These glossaries will be added to from time to time in the future. Anyone failing to grasp the meaning of terms used should get 99 or 130 and make use of their glossaries. They are free for the asking. The larger bulletin is always thoroughly indexed.

The following statement outlines the "features" of the preceding bulletins. The table of contents on pages 59-60 serves to introduce the reader to the matter contained in this issue:

Bulletin 93 (1902). *Formulas for home mixing.*—The nature and composition of the crude stock or ingredients used, suggestions as to their choice for sundry uses and as to their compounding, together with many formulas, using all sorts of crude stock and providing for almost every conceivable grade of goods. (56 pages).

Bulletin 99 (1903). *Vermont's usage of fertilizers.*—A review of data drawn from the last census, showing usage by counties; a comparison of commercial fertilizer consumption in Vermont and in other states.

Concerning fertilizer buying.—An exposition of the meaning of guaranties; of the lack of meaning to brand names; of the true inwardness of the valuation system, what it is and what it is not, arguments for and against it and the method of its use; of the agricultural value of a fertilizer, and the distinction between agricultural and commercial values; and of the forms of plant food.

Deficient plant food.—A discussion of the nature and functions of the sundry forms of nitrogen, phosphoric acid, potash, and lime, together with statements concerning the effect of lime on soils, on plants, and the practice of liming. (88 pages).

Bulletin 108 (1904). *Classification of commercial fertilizers sold in Vermont.*—An arrangement of 123 brands sold in 1904 according to the amounts and character of their guaranteed plant food contents, made with a view of aiding the purchaser in his commercial choice.

Farm manures.—A classification and definition of the various forms of plant food; a review of Vermont's usage of plant food; a discussion of the chemical composition, the physical characteristics and the wastes of farm manures and of their application and use. (68 pages).

Bulletin 116 (1905). *How, when and what to use.*—A critical survey of systems of fertilization, of methods of application, of the sundry schemes suggested whereby some clue as to soil and crop needs may be gained, together with a very full series of fertilizer formulas for grasses, clovers, corn, cereals, roots, potatoes, vegetables, fruits, flowers and tobacco. (104 pages). (Available only as a loan).

Bulletin 123 (1906). *Concerning the purchase of plant food.*—A discussion of methods of buying mixed goods and separate ingredients.

The moisture relations of the soil, especially as regards conservation and control of soil water, through irrigation, drainage, and particularly the sundry tillage operations. (68 pages).

Bulletin 130 (1907). *Soil biology in its relation to fertilization.*—A review of the relationship of soil organisms to soil usage, including statements as to microorganisms, their nature and classification; bacteria, their propagation and environment as to food, aeration, light, temperature, moisture and location, as to the prevalence of other forms, and as to the accumulation of their life products. Particular reference is made to soil bacteria affecting mineral ingredients in the dissolution of mineral plant food and to those affecting organic ingredients. Under the latter head is discussed decomposition in general, manurial decomposition in particular, nitrification, nitrogen fixation by bacteria in association with legumes, including nitrogen assimilation, and by bacteria unassociated with higher plants, including soil inoculation, also nitrogen elimination, including denitrification. The nitrogen cycle, and non-bacterial nitrogen losses are discussed and a balance struck of nitrogen gains against nitrogen losses. A partial list of literature consulted and a glossary are included. (144 pages).

The remarks above outlined were written in 1902, 1903, 1904, 1905, 1906 and 1907; but they are just as applicable to the purchase and use of fertilizers in 1908 and succeeding years as they were when first penned. The reader of this bulletin who does not own a 93, a 99, a 108, a 123 or a 130, and wants either or all of them, has but to ask to receive. No. 116, being nearly exhausted, is only issued on loan to those who will promise to return it after it has served their purposes.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate ingredients used to manufacture the same, or * * * bone meal, land plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.)

It provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in distilled water, and of soluble, reverted, insoluble, available and total phosphoric acids, and the maximum percentage of chlorin." (Sec. 4976 P. S.)

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) " * * * shall annually * * * pay * * * a license fee of one hundred dollars," which will permit "the sale of not more than five brands of commercial fertilizer, which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than this number of brands, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of five." "The license fee(s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S.)

It provides that any person offering unguarantied, overguarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the state treasurer, for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs. 4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.) The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.)

The full text will be furnished on application.

LIST OF LICENSEES

The following companies have paid licenses as required by law on the brands shown in the tables on pages 95-105, and on the one brand mentioned on the next page as uncollected. The sale within the State of these brands, and of these brands only, is legal. All local agents as well as intending purchasers are warned against the handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the one hundred dollars license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 2 Rector St., New York.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
Buffalo Fertilizer Co., William St., near city line, Buffalo, N. Y.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 24-26 Stone St., New York.
Essex Fertilizer Co., 39 No. Market St., Boston.
Lister's Agricultural Chemical Works, Newark, N. J.
Lowell Fertilizer Co., 44 No. Market St., Boston.
New England Fertilizer Co., 42 No. Market St., Boston.
Parmenter & Polsey Fertilizer Co., 40B No. Market St., Boston.
Rogers & Hubbard Co., Middletown, Conn.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 69 towns and villages in Vermont during the spring of 1908 and drew 274 samples from dealers' stocks, representing 130 distinct brands, the output of 11 companies licensed to sell in Vermont. These companies licensed 131 brands.[1] No shipments of the Buffalo Fertilizer Co.'s Extra Bone and Potash were found by the sampling agents.

SCHEDULE OF TRADE VALUES

The following schedule of trade values to be used in this State in 1908 is the one agreed upon by the Experiment stations of New England and New Jersey, after a careful study of prices ruling in the larger markets. It is identical with the schedule used last year.

---

[1] Since the issuance of Bulletin 126 the Parmenter and Polsey Fertilizer Co. has licensed the sales of the Aroostook Special, Special Potato, Potato, and Potato Grower goods, and the American Agricultural Chemical Co. the sale of the Crocker's High Grade Special and the Crocker's New York Special. The following errors are noted in the list as given on pages 39 and 40 of Bulletin 134: American Agricultural Chemical Co. General Lawn and Top Dressing should read Grass and Lawn Top Dressing; Coe-Mortimer Co. "Ammo. Bone Superphos." is a printer's error and does not exist; Essex Fertilizer Co.'s Grass and Grain Fertilizer omitted.

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MA AND CHEMICALS FOR 1908

	cts
Nitrogen in nitrates	
Nitrogen in ammonia salts	
Organic nitrogen in dry and fine ground fish, blood and meat and in mixed fertilizers	
" " in fine ground bone and tankage	
" " in coarse bone and tankage	
Phosphoric acid soluble in water	
" " soluble in ammonium citrate[1]	
" " in fine ground bone and tankage	
" " in coarse bone and tankage	
" " insoluble (in water and in ammonium citrate[1]) in mixed fertilizers	
Potash as high grade sulphate and in mixtures free from muriate (chlorid)	
Potash as muriate	

These trade values are, as nearly as can be estima average figures at which, in the six months preceding Ma the respective ingredients could be bought at retail for cas larger markets (Boston, New York, etc.), in the *raw m* unmixed. They also correspond to the average wholesal for six months ending March 1st, plus about 20 percent case of goods for which there are wholesale quotation: valuations obtained by the use of the above figures will b to agree fairly with the reasonable average retail price large markets of standard raw materials.

In applying trade values to mixed goods, organic nitr valued at 20½ cents a pound; nitrogen as nitrate of soda sulphate of ammonia at 18½ and 17½ cents a pound respe soluble, reverted and insoluble phosphoric acids at 5, 4½ cents a pound respectively; and potash at 4¼ cents a po there is sufficient chlorin to unite with all the potash; if is valued at 5 cents.

A valuation is determined as follows: The percenta pounds per hundred of each ingredient (i. e., nitrate ni ammoniacal nitrogen, organic nitrogen, soluble phosphori reverted phosphoric acid, insoluble phosphoric acid and p are multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

---

[1] Dissolved from 2 grams of the prepared sample previously extract pure water, by 100 c.c. of a neutral solution of ammonium citrate, sp. in 30 minutes at 65 degrees C, with agitation once in five minutes.

THE MEANING OF COMMERCIAL VALUES

That there may be no misconception and that the reader may clearly appreciate what these valuations are and what they are not, it is our custom to call attention repeatedly to the fact that *a station valuation does not represent the proper selling price of a fertilizer at the point of consumption.* Neither should it be inferred that the ingredients in the brand in question have of necessity the commercial value indicated. It may be greater or less than is shown. The Station does not pretend dogmatically to state what may be the commercial worth or valuation of any one of the many brands of fertilizer sold in the Vermont market, as it cannot always affirm the quality of the crude stock used, particularly the nitrogenous material. The valuation system is based on the assumption that all brands are composed solely of high grade ingredients, an assumption which is probably erroneous. "Valuations" should not be construed as showing the commercial worth of a given fertilizer, but the *retail trade value or cash-cost of amounts of nitrogen, phosphoric acid and potash, equal to those contained in a ton of the brand in question, in unmixed, standard raw materials of good quality, at the seaboard.*

Valuations thus construed, while not infallible, are helpful:

(*a*) To show whether a given fertilizer is worth its cost from the *commercial* standpoint.

(*b*) As a common basis on which to compare the *commercial* values of different brands, enabling buyers to note whether prices asked are warranted by values contained.

Valuations, then, simply show the cost of ready-made plant food. Its cost, however, is but one of the many charges which determine the retail cost of commercial fertilizers. The plant food when ready for use must be mixed, stored, reground, bagged, loaded, and freighted. Then, too, commissions to agents and dealers, the expense of selling on long credit, the item of bad debts, the interest on investments, the depreciation of the manufacturing plant, profits, etc., are also proper and fixed charges; yet not one of them contributes to plant growth. Commercial fertilizers are usually applied in the mixed form, but this is simply a matter of convenience, for as good results may be obtained by the separate application of the crude ingredients.

An illustration may serve to make these statements more clear. A farmer buys in Boston or New York 50 pounds of nitrate of soda, 350 pounds of dried blood, 1475 pounds of acid phosphate, and 125 pounds of muriate of potash, and he mixes these ingredients together at home on his barn floor, as thousands have done before him. The cost of this ton after mixing will be made up as follows: (*a*) Cost of material in the market; (*b*) cost of transportation; (*c*) cost of mixing. The first item (*a*) entering into the total cost is the only one included in the "valuation." If to (*a*) be added (*b*), (*c*), and, also, the expenses of selling through agents, long credits, bad debts, etc., we have the factors involved in the cost of fertilizers delivered in Vermont. Clearly the local selling price must of necessity exceed the "valuation." Since the cost of mixing and selling varies with different companies, and since freight rates to the different sections of the State are unlike, no arbitrary sum to cover these charges can be assigned. These can be estimated best by the consumer to fit his local conditions. If the selling price does not exceed the valuation more than 35 or 40 percent it may not be too high, but in proportion as the excess increases beyond this point there is reason to question the economy of the purchase. The reader is referred for a further and somewhat full discussion of this matter to pages 81-86 of bulletin 99 (sent without charge on request); also to pages 83-91 of this issue.

III. RESULTS OF FERTILIZER INSPECTION

1. AS TO QUANTITY OF PLANT FOOD

(a) COMPARISON OF GUARANTIES AND ANALYSES

More than a quarter of the brands sold fail to make good their guaranties in one or more ingredients; and a considerable number, six, do not furnish plant food in amounts equivalent commercially to the promises of the sellers, though in four of the six cases the shortages are too small to indicate any attempt to defraud. The plant food deficiencies are quite evenly distributed between the three ingredients, being 13, 13, and 16 respectively, for nitrogen, available phosphoric acid, and potash. It is but fair to state, however, that a third of the 42 deficiencies are but slightly over the 0.10 or 0.20 percent mark.[1]

Nine of the eleven companies contribute brands to the delinquent list. One company furnishes a single brand; two others two apiece; yet two others three apiece; three others four apiece; being in two cases more than half the total number sold; while one company selling 59 brands furnishes a quarter of them to this list.

American Agricultural Chemical Co.—Fifteen brands are deficient, six of which are only slightly over the line. In all cases but one a commercial equivalent of the promised plant food is present. The shortage in this case is very slight.

Bowker Fertilizer Co.—Four brands are deficient, one being just over the permissible limit. The commercial equivalent is not afforded in one case; but the money shortage would hardly do more than buy a cheap cigar.

Buffalo Fertilizer Co.—Three brands are deficient, one in two and one in all three ingredients. The commercial equivalent of the guaranty is furnished in two brands; but concerning the third it was said in bulletin 134 that "a sample of the Buffalo Fertilizer Co.'s Vegetable and Potato Fertilizer drawn at Montpelier was found lacking in all three forms of plant food. It was resampled and reanalyzed with essentially identical results. The shortage in commercial value is in excess of 10 percent. This failure to meet the requirements of the Public Statutes has been reported to the State's Attorney of Washington County."

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[1] A brand which analyzes within 0.10% nitrogen or 0.20% phosphoric acid of potash of guaranty is deemed to be up to guaranty.

Coe-Mortimer Co.—Four brands are deficient, two of which failed to make good the commercial equivalent of the guaranty, in one case—Columbian Corn and Potato—by quite a margin.

Essex Fertilizer Co.; Lister's Agricultural Chemical Works.—These companies contributed respectively two and one brands each to the list. One of the former was but slightly deficient. Commercial equivalents were afforded in each case.

Lowell Fertilizer Co.—Two brands deficient, one in two ingredients, the other being barely over the line. An ample amount of plant food was present in each case to make good the commercial equivalent.

Parmenter & Polsey Co.—Four brands were deficient, two barely so, one seriously so, failing to make good the commercial equivalent of the guaranty. This case may have been one of error in shipment.

Rogers & Hubbard Co.—Three brands were deficient, one but slightly, two decidedly. In each case overwhelming excesses of other forms of plant food were present. Several of the brands are somewhat difficult to mix evenly because of high grade.

Attention is once more called to the fact that 12 of the 38 brands are so slightly lacking as to be only technically deficient; and that only 6 fail to make good the money value of their manufacturers' promises. In other words, inadequate mixing, which affords considerable excesses of some one or more ingredients balancing greater or less deficiencies of others, seems at fault in five-sixths of the brands; while of the 6 in which actual shortage occurs in money value but two are seriously deficient.

It is perhaps needless to remark that *the statements made on these two pages are not implications of the agricultural values of these goods.* They simply call attention to a fact, viz.: that certain brands do not carry as much of certain forms of plant food as their several manufacturers state they contain. With a few of these goods, however, they are a fairly plain intimation to their manufacturers as to the advisability of one of two procedures, the revision of the guaranties or the fortification of the goods. There were ten goods thus pilloried in 1905, eight in 1906, and nine in 1907. Four of this year's six deficients have been hitherto found short and three have been specifically mentioned at this point in two of the last three annual fertilizer bulletins. The deficiencies of one in two successive years have been such as to necessitate reference to the courts.

Whenever guaranties were not made good the analytical work was repeated, and, frequently, recourse was had to other samples, taken a second time from the original shipments. In several cases when results seemed open to question, other samples were elsewhere drawn. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were also instituted with a view of minimizing error and standardizing results. This general procedure has been in vogue at this Station for years, and is thought to minimize to the last degree the likelihood of error in sampling or analysis.

The condensed results of 14 years' inspection of the Vermont fertilizer trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1895	92	76	16	83	95
1896	110	91	19	83	99
1897	134	113	21	84	94
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	93	38	71	94
1906	130	110	20	85	98
1907	129	98	30	77	94
1908	130	92	38	71	95

The following table shows the number of brands sold b the different companies licensed in the State, the number of guar anties (nitrogen, available phosphoric acid, potash) made b each and the number of failures to make the same good withi 0.10 percent of nitrogen or 0.20 percent of available phosphori acid or potash:

MAINTENANCE OF GUARANTIES BY LICENSEES

Name of company	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands not making good the commercial equivalent of the
American Agricultural Chemical Co.......	2	6	0	0
do. H. J. Baker & Bro. Branch......	3	9	1	1
do. Bradley Fertilizer Co. Branch....	10	29	3	0
do. Clark's Cove Fert. Co. Branch..	3	9	0	0
do. Cleveland Dryer Co. Branch....	3	9	0	0
do. Crocker Fert. & Chem. Co. Branch	7	19	2	0
do. Cumberland Bone Phos.Co.Branch	2	6	1	0
do. L. B. Darling Co. Branch........	2	6	0	0
do. Great Eastern Fert. Co. Branch..	5	14	2	
do. Pacific Guano Co. Branch.......	3	9	0	
do. Quinnipiac Co. Branch..........	4	12	0	
do. Read Fertilizer Co. Branch......	6	17	4	
do. Henry F. Tucker Co. Branch....	3	9	1	
do. Williams & Clark Fert. Co. Branch	6	18	1	
American Agricultural Chemical Co..Total	59	172	15	
Bowker Fertilizer Co.	15	44	4	
Buffalo Fertilizer Co.	6	17	6	
Burlington Rendering Co.	2	6	0	
Coe-Mortimer Co.	6	17	4	
Essex Fertilizer Co.	6	18	2	
Lister's Agricultural Chemical Works......	9	26	1	
Lowell Fertilizer Co.	8	24	3	
New England Fertilizer Co.	5	15	0	
Parmenter & Polsey Fertilizer Co.........	7	21	4	
Rogers & Hubbard Co.	7	21	3	
Total...........................	130	381	42	

The range of composition and the closeness with which gu anties are met are shown in the first table on the following pa The condition of affairs it discloses, a close hugging of the gu anty, has obtained for years, as appears in the second table, wh shows the excess of the average analysis over the average guaranty for five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average 8 percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

GUARANTIES, ANALYSES, SELLING PRICES AND VALUATIONS

	PERCENT GUARANTEED			PERCENT FOUND			
	Lowest	Highest	Average	Lowest	Highest	Average	Excess of average analysis over guaranty
Nitrogen,	*0.82	8.5	†2.02	0.88	8.70	†2.20	0.18
Total phos. acid,	5.	16.	9.19	6.84	16.40	10.43	1.24
Available phos. acid,	3.9	11.	7.64	4.44	11.16	8.14	0.50
Potash,	1.	12.	4.25	1.23	14.46	4.58	0.33
Selling price,	$22.00	$60.00	$31.24				
Valuation,	$11.26	$43.40	$19.06	$11.98	$47.22	$20.75	$1.69

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSES OVER GUARANTIES

	1904	1905	1906	1907	1908	Average for five years
Nitrogen,	0.28	0.22	0.28	0.20	0.18	0.23
Total phosphoric acid,	1.30	1.49	1.58	1.21	1.24	1.36
Available phos. acid,	0.62	0.54	0.67	0.45	0.50	0.56
Potash,	0.26	0.27	0.37	0.35	0.33	0.32
Valuation,	$2.00	$1.86	$2.47	$1.61	$1.69	$1.93

While the statement shows that the goods compare well on the average with the claims made for them, the tables on pages 95-105, not to speak of the statements on pages 71 and 72, betray the fact that within this average lie concealed several deficiencies, as well as some failures to proportion the plant food as is promised. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guaranteed is not furnished

*No nitrogen in nine brands.
†Non-nitrogenous goods omitted; if included, average drops 0.13 percent.

to know that the "average" is good. It is for him to exercise care and to avoid buying such goods. Yet it should be said that *seriously* faulty fertilizers, so far as guaranty maintenance is concerned, are not common this year.

(*b*) COMPARATIVE VALUES OF FERTILIZERS OF 1907 AND 1908

Of the 145 brands of commercial fertilizers which were sampled by our agents during 1907 and 1908, 114 have been selected for comparison of the characters of the goods sold under these brands in each of the two years. Only those brands have been chosen which have been sampled both years.[1] The table shows practically no change in nitrogen or potash and but slight increase in phosphoric acid, one year as compared with the other:

AVERAGE COMPOSITION OF FERTILIZERS IN 1907 AND 1908

Name of ingredient	1907		1908	
	Pounds in a hundred	Valuation at 1908 prices	Pounds in a hundred	Valuation at 1908 prices
Nitrogen,*	2.14	$8.77	2.11	$8.65
Soluble phosphoric acid,	4.50	4.50	4.59	4.59
Reverted phosphoric acid,	3.46	3.11	3.54	3.19
Insoluble phosphoric acid,	2.34	0.94	2.30	0.92
Total phosphoric acid,	10.30	....	10.43	....
Available phosphoric acid,	7.96	....	8.13	....
Potash,*	4.49	3.82	4.49	3.82
Total valuation pe rton,		$21.14		$21.17

*Nitrogen calculated as all organic; potash calculated as muriate.

(*c*) COMPARATIVE VALUE OF FERTILIZERS, 1895-1908

The next table shows the average composition of the fertilizers as analyzed during the past fourteen years. Every brand tested each year is included in the comparison, each one being

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[1] The Essex goods similarly named each year, but offered by two different companies, are omitted.

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1895 TO 1908*

Year	Number of brands	Nitrogen	Soluble phosphoric acid	Reverted phosphoric acid	Insoluble phosphoric acid	Total phosphoric acid	Available phosphoric acid	Potash
1895......	92	2.22	5.84	2.56	2.23	10.93	8.40	3.46
1896......	110	2.22	5.36	3.44	2.23	11.02	8.80	3.66
1897......	134	2.12	5.34	3.68	2.23	11.25	9.02	3.43
1898......	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81
1899......	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10
1900......	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80
1901......	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33
1902......	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21
1903......	111	2.02	5.13	3.42	2.50	11.05	8.55	3.97
1904......	117	1.98	5.20	3.19	2.38	10.77	8.39	3.95
1905......	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18
1906......	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37
1907......	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65
1908......	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58

AVERAGE COST OF FERTILIZERS SOLD IN VERMONT IN 1895 TO 1908

Year	Number of brands analysed	Average selling price per ton	Average valuation at each year's trade values	Excess of selling price over valuation	Percentage excess of selling price over valuation	Value of plant food received for each dollar paid out	Average valuation at 1908 trade values†
1895.....	92	$30.90	$21.28	$ 9.62	45	69 cts.	$20.85
1896.....	110	30.90	19.73	11.17	57	64 "	21.34
1897.....	134	29.19	19.47	9.72	50	67 "	20.94
1898.....	126	29.04	17.86	11.18	63	61 "	21.41
1899.....	137	28.75	17.39	11.36	65	60 "	20.70
1900.....	132	28.73	18.08	10.65	59	63 "	20.80
1901.....	134	28.75	19.44	9.31	48	68 "	21.20
1902.....	136	28.23	20.18	8.05	40	71 "	21.73
1903.....	111	28.25	18.59	9.66	52	66 "	20.62
1904.....	118	29.00	18.47	10.53	57	64 "	20.31
1905.....	130	‡29.62	19.18	10.58	56	64 "	20.72
1906.....	130	‡29.52	19.38	10.14	52	66 "	21.11
1907.....	129	‡30.57	21.21	9.36	45	69 "	21.19
1908.....	130	‡31.24	20.75	10.49	51	66 "	20.81

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*See footnote (¹) on succeeding page.

†Assuming one-quarter of nitrogen as nitrate and all potash as muriate.

‡Several brands new in Vermont since 1905 selling at $40 to $60 raise these figures inordinately. If these are omitted the average drops about a half dollar to a figure which is doubtless nearer truth.

given equal value, which, while not strictly a correct method of calculation, is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods sell slowly and, unfortunately, low grade brands sell as a rule readily, the actual average as used is probably somewhat lower than that shown in the table on page 77.[1]

The average commercial fertilizer sold in Vermont in 1908 contains a tenth percent less nitrogen and a tenth percent less potash, but 0.14 percent more available phosphoric acid than that sold in 1907. The increase in the averages of the past four years, as compared with those of previous years, is due to the somewhat unusual character of certain goods sold for the first time in 1905, and to the entry last year of several relatively high grade goods. A survey of the table indicates that no profound change has taken place during the fourteen years. Indeed there seems to be three periods of four, six and four years respectively wherein there are wide differences in the average plant food content of the average goods, particularly in phosphoric acid and potash, as shown below:

1895-98........nitrogen 2.19, available phosphoric acid 8.75, potash 3.60
1899-04........nitrogen 2.07, available phosphoric acid 8.51, potash 4.06
1905-08........nitrogen 2.08, available phosphoric acid 8.19, potash 4.45

The average grade goods are better to-day than hitherto; but that is not saying that there are not many inferior ones on the market.

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[1] It ought to be remarked at this point that neither this table, nor the table which immediately precedes it, nor the discussion of this matter, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made in 1904 to estimate the relative usage of the different grades, but without much success. No data is available that is trustworthy, while if one appeals to the individual judgment of those who are in closest touch with the trade the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used at 1.80 to 1.90 percent nitrogen, 8.50 percent available phosphoric acid and 3.25 to 3.50 percent potash.

At what prices did the sundry forms of available plant food sell in the average mixed fertilizer of these years?

COST OF PLANT FOOD IN THE AVERAGE MIXED FERTILIZER, 1895 TO 1908

Year	Number of brands analyzed	Cost of one pound of organic nitrogen	Cost of one pound of available phosphoric acid	Cost of one pound of potash (as muriate)
1895	92	23.9 cts.	8.7 cts.	6.5 cts.
1896	110	22.0 "	8.6 "	7.1 "
1897	134	21.0 "	8.3 "	6.8 "
1898	126	22.8 "	7.3 "	6.9 "
1899	137	23.1 "	7.4 "	7.0 "
1900	132	24.6 "	7.1 "	6.7 "
1901	134	23.7 "	7.4 "	6.3 "
1902	136	23.1 "	7.0 "	6.0 "
1903	111	25.9 "	6.8 "	6.5 "
1904	118	27.5 "	6.9 "	6.7 "
1905	130	28.9 "	6.8 "	6.6 "
1906	130	28.3 "	6.6 "	6.4 "
1907	129	29.6 "	6.9 "	6.1 "
1908	130	30.5 "	7.1 "	6.3 "

The tendency during the last three years has been towards increased selling prices, particularly in medium and high grade goods, and higher valuations. The cost of nitrogenous crude stock increased sharply some six years ago, and it is still rapidly going up in price. This change has resulted in raising valuations, as shown in the table on page 77.

2. AS TO QUALITY OF PLANT FOOD

(*a*) SOURCES OF PLANT FOOD IN LICENSED FERTILIZERS

The table on page 75, as well as those on pages 95-105, show wide ranges in composition, amounts of nitrogen varying from 0.88 to 8.70 percent, of available phosphoric acid from 4.44 to 11.16 percent, and of potash from 1.23 to 14.46 percent. These figures alone, however, do not tell the whole story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food of the various brands is derived.

NITROGEN

Ten of the eleven fertilizer manufacturers used more or less water-soluble nitrogen (as nitrate of soda or as sulphate of ammonia) in one or more of their brands. Four used it in most of their brands and have habitually done so for years, while six used it in from one to three brands. More or less water-soluble nitrogen was present in 60 percent of those brands which contained nitrogen, the amounts varying from 0.23 to 7.72 percent and averaging 1.08 percent (41 percent of the total nitrogen present in these brands). Under certain circumstances and for certain purposes water-soluble nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available, but more easily lost by leaching. (See pages 89-90, bulletin 99). All the brands but one which carry nitrogen contain more or less organic nitrogen. In 40 percent of them organic nitrogen is the only form present, derived, no doubt, as a rule from standard animal and vegetable ammoniates such as dried blood, meat meal, fish scrap, tankage, cottonseed meal, etc. Probably tankage is at present its main source in the great majority of brands. It is safe to say that in general the sources of organic nitrogen have been of good grade.

Available nitrogen.—Every brand carrying organic nitrogen was tested by the alkaline-permanganate distillation method,[1] as has been done yearly for ten years. This method, as has been pointed out hitherto, affords results which have comparative rather than absolute values.

The subjoined table shows the organic and total nitrogen availabilities of the average goods made by each firm as measured by this method. Each brand is given equal value in the average. The figures are arranged in the general order of their excellence, yet since practically no difference exists between averages in several cases (for the difference between 62 and 60 for instance is but slight), no stress should be laid upon the exact order of statement. Inasmuch as the method used in determining the availability of organic nitrogen is empirical, firm names are omitted:

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[1] Vt. Sta. Rpts. 11, pp. 160-171 (1898); 12, pp. 137-139 (1899); 14, pp. 219-221 (1901).

	Percent of organic nitrogen available	Percent of total nitrogen available		Percent of organic nitrogen available	Percent of total nitrogen available
A	66	77	G	63	64
B	66	75	H	60	71
C	64	66	I	61	65
D	61	78	K	60	62
E	63	67	L	58	58
F	62	66			

As to grade.—The availability of the organic nitrogen of brands low in that ingredient tended as a rule to be somewhat less than that of the brands which may be termed medium or high class goods. This has been the case every year since this method of analysis has been in vogue at the Station. There are occasional exceptions to this general statement; yet, speaking broadly, the nitrogen of some low grade brands seemed to lack somewhat in quality as well as in quantity.

As to manufacture.—No exception can be taken to the character of the organic nitrogen used this year save with one low grade brand sold by a company whose other goods were all that could be asked for in this respect. This sample showed an availability as measured by permanganate of 30, as measured by pepsin of 42. It seems highly probable that inert nitrogenous material was employed in its manufacture.

PHOSPHORIC ACID

Some of the manufacturers furnish relatively a larger proportion of the total phosphoric acid in available form than do others; and, again, some, more of the water-soluble relative to the citrate-soluble or reverted than do others. Water-soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate-soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumnia phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as valuable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 43 percent to 94 percent. The proportions of available phosphoric acid found to be in a water-soluble form varied from 19 percent to 81 percent.[1] Grouped according to their manufacture it was found that extremes for available in total were 66 and 87 percents, for water-soluble in available 44[1] and 65 percents. In other words, the average goods made by one firm carried 87 percent of the total phosphoric acid in available form, while those made by another firm furnished but 66 percent in that shape, the remainder ranging between. Similarly, on the average 65 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 44 percent was thus soluble in the average goods of another firm. The low availability seems to be due in some cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause, to imperfectly cut phosphate rock, to the age of the goods, to the use of agriculturally inferior forms of phosphoric acid, or to other causes does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, rarely, nitrate. The direct or inferential claim is made for three-fifths of the brands that sulphate of potash is used in their manufacture. This is often merely a subterfuge, is intentionally misleading, and is not borne out by the facts. It is doubtless not illegal for a manufacturer to indicate an equivalence, since such an expression is not strictly speaking a guaranty, but simply a part of that surplusage with which manufacturers are apt to bedeck fertilizer sacks. Six of the eleven companies selling in Vermont do not try thus to mislead their customers; five, however, for many or all the goods made this doubtful statement. The American Agricultural Chemical Company makes this inferential claim by the use of the phraseology "equivalent to sulphate of potash," for 58 brands; the Bowker Fertilizer Company, for 11 of 15 brands; the Lowell Fertilizer Company, for 6 of 8 brands; the Burlington Rendering Company, for 1 of 2 brands; and the Rogers & Hubbard Companl, for 1 of 8 brands. Sulphate is the main or only source from which the potash in the single Rogers & Hubbard brand just referred to is derived. Either it is not used in a single one of the other 77 brands; or else enough chlorin is present therein in each case to neutralize its good effects, if any such there be. Only three brands out of the entire 130 carried sulphate of potash, and one of these but in minor amounts. Wherever the asterisk (*) appears against the station number at the left of the analysis and against the potash figures in the columns thus headed in the tables on pages 95-105, sulphate (or possibly, nitrate) of potash was found to be present; where these signs do not appear the potash was derived doubtless from muriate or kainit.

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[1] Exclusive of six brands of unacidulated goods, mixtures of bone or tankage with chemicals.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for over a decade. It has been customary of late to approach the matter from two directions, to make two classifications, basing one on *cost* and the other on *value*. Three groups, somewhat arbitrarily formed, designated "low priced," "medium priced" and "high priced," furnish the means of comparing the cost, while as many groups termed "low grade," "medium grade" and "high grade" serve the purpose in the study of relative values.

When grouped according to selling prices the item of *cost* is emphasized; when the valuations govern the sub-divisions, the stress is laid upon the *worth* of the material. The selling price may or may not bear an essentially just relation to the plant food content of the fertilizer. The valuation, however, is a more exact measure. Since both cost and worth are important factors, and since some may grasp the facts more readily when presented from one viewpoint while others see the situation better when looked at from the other side, it has been deemed best to present the results of both methods of comparison. The general outcome is much the same either way the proposition is figured.

1. FROM THE STANDPOINT OF COST

The brands may be classified as to selling price as follows:

	Number of brands	Percent of total	Average selling price
Low priced, selling at $28 or below......	39	30	$26.18
Medium priced, selling from $28.50 to $33	57	45	29.60
High priced, selling for $34 or more....	32*	25	38.03

The average, largest and smallest values of plant food offered in the groups of brands appear below. The figures show the values of plant food bought for a dollar in the average goods of each grade, including the greatest as well as the least value obtained in any brand in each class.

VALUE OF PLANT FOOD BOUGHT FOR A DOLLAR

	Average	Smallest	Largest
Low priced	$0.58	$0.48	$0.71
Medium priced	0 67	0.52	0.78
High priced	0.73	0.61	0.87

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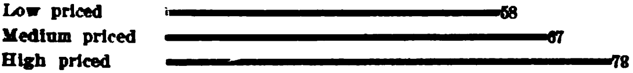
*A highly nitrogenous and relatively costly oats and top dressing and a high priced tobacco goods omitted from the comparison.

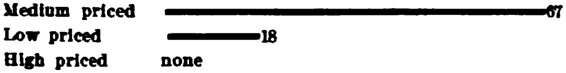
It is interesting to note the number of brands in each group which furnish less than 60 cents' worth of plant food[1] for a dollar, as well as the number which afforded more than 70 cents' worth for the same sum:

Low priced: Less than 60c. worth, 26; more than 70c. worth, 2.
Med. priced: Less than 60c. worth, 10; more than 70c. worth, 10.
High priced: Less than 60c. worth, 0; more than 70c. worth, 22.

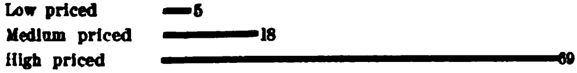
The comparisons can be shown graphically. The relative length of the following lines show the average money value in plant food at retail seaboard prices bought for a dollar at Vermont delivery points in brands selling for $28 or less (low priced), from $28.50 to $33 (medium priced), and for $34 and above (high priced):



The following lines show the proportion of the total number of brands in each group containing 60 cents or less worth of plant food for each dollar invested:



The final set of lines show the proportion of the total number of brands in each group containing 70 cents or more worth of plant food for each dollar invested of the purchase price:



If lines and figures are put into words, it will be seen that:

1. The same amounts of plant food which cost a dollar in the average low priced brands ($28 and below) might have been bought in the unmixed state at retail and at the seaboard for 58 cents; in the average medium priced goods ($28.50 to $33) for

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[1] The phrase "60 cents' worth of plant food" should be construed to mean an amount of plant food which, if bought for cash at retail at the seaboard, would have cost 60 cents in standard, unmixed, raw materials.

67 cents; and in the average high priced goods ($34 and u wards) for 73 cents. Extremes of values were 87 and 48 cent In more than a quarter of the brands the sums charged for manu facture, transportation, sale, etc., comprised 40 percent or mor of the retail cost, thus leaving only 60 percent or even less t pay for the plant food.

2. In two-thirds of the total number of low priced brand the charges for mixing, sale, etc., aggregate at least 40 percen of the selling price, while in only one in five of the number o medium priced brands and in none of the high cost goods wer the charges thus large.

3. Two out of three of the total number of high class good contained an equivalent of 70 cents or more worth of plant foo at retail seaboard prices. But one in five of the medium and one in twenty of the low grade goods contain so high an equivalent.

These things are naturally so, inevitably so. There are good and sufficient reasons for this showing, which may be condensed in a nutshell as follows: It costs as much to mix, to store, to regrind, to bag, to ship, to freight, to sell, to collect for sales, etc., a ton carrying 1,200 pounds of genuine fertilizer and 800 pounds of mere filler (diluent)[1] as one that contains 2000 pounds of undiluted fertilizer ingredients. Therefore the buyer of low grade goods must pay for all this useless handling of the nearly or quite worthless filler. It is an old story, reiterated year after year, but it is one which needs to be told as long as there is such a usage of low grade brands as now obtains.

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[1] A word or two as to filler. The American Fertilizer, the organ of the trade, recently printed a speciously written article on "The Filler in Fertilizers," in which the idea is inculcated that the entire bulk of the goods other than the plant food (nitrogen, phosphoric acid, potash) percentages is filler; that the sodium of nitrate of soda, the lime of the phosphate rock, the chlorin of the muriate, are filler; that filler is an inevitable and natural ingredient of any fertilizer. It intimates that "this is what filler is and how it gets into fertilizer bags; that great bogy which professors, lecturers and others . . . hold up to view." The entire argument is meant to throw dust (shall we say filler?) into the buyers' eyes. No one with the slightest knowledge regarding fertilizers ever called these natural and necessary materials "filler." Filler is well understood to be the diluent added to the plant food bearing ingredients, itself devoid of or low in plant food content. Marl, cinder, fuller's earth, coal ashes, peat, etc., are fillers; and few low grade goods, other than non-nitrogenous ones, fail to contain more or less thereof.

2. FROM THE STANDPOINT OF VALUE

Let us now turn the matter about and study it from the standpoint of *worth*. The figures and proportions naturally differ from those just presented. The brands may be classified as to valuation as follows:

	Number of brands	Percent of total	Average valuation
Low grade, valuing at $17.50 or less.........	43	34	$15.14
Medium grade, valuing at $17.51 to $23.50....	53	41	20.09
High grade, valuing at $23.51 and upwards..	32	25	28.03

The composition, selling price and valuation of the average brand of each group appears below:

	Nitrogen	Available phosphoric acid	Potash	Total plant food, pounds	Average selling price	Average valuation	Selling price exceeds valuation by
Low grade,	1.01	8.78	2.37	12.1	$27.03	$15.14	$11.89
Medium grade,	2.24	8.46	4.22	14.9	29.73	20.09	9.64
High grade,	3.30	7.25	8.44	19.0	38.08	28.03	10.05

A survey of this table indicates that:

1. The proportion of nitrogen increases in regular graduations from group to group; that of phosphoric acid remains fairly constant in the first two, but drops in the third group; while the potash increases two percent in the medium and six percent in the high grade brands, as compared with the lower ones.

2. The low grade goods carry nearly nine times as much phosphoric acid as they do nitrogen and nearly four times as much phosphoric acid as they do potash. These proportions become, roughly, four and two in the medium grade. In the high grade fertilizers there are but two and one-fifth times as much phosphoric acid as nitrogen, and over a percent more potash

than phosphoric acid. The latter grade more closely resembles the proportions commonly present in the crops ordinarily grown than do either of the other grades.

A study of the main tables and of the data in hand further shows that seven of the eight high grade goods and nearly three out of four medium grade brands contained either nitrate or ammonia salts (water-soluble nitrogen). Only one brand in six of the low grades contained this valuable form of plant food. Moreover, the organic nitrogen availability of the low grade goods tended to run somewhat lower than that of the better classes.

3. The medium grade goods, for one-twelfth advance in price over the cost of the low grade brands, offer nearly one-fourth more plant food and a third more commercial value.

4. The high grade fertilizers for but 40 percent advance in price over the cost of the low class goods, furnish nearly 60 percent more plant food and a commercial value greater by 86 percent.

5. The higher the grade the less the margin between cost and worth, both actually and relatively. In buying the average low grade brand one paid this year $11.89 for service of one sort or another (factory and office charges, freight, selling expenses, etc.) incurred in the delivery of $15.14 worth of plant food; when medium grade goods were bought, $9.64 service charges placed $20.09 worth of plant food in the buyer's hands; and when high grade goods are bought $10.05 service charges placed $28.03 worth of plant food in the buyer's hands. Or, phrasing the matter another way, *the cost of placing a dollar's worth of plant food in the farmer's hands* was:

In low grade goods	78 cents
In medium grade goods	48 cents
In high grade goods	36 cents

It may be worth while now to scan the prices paid for a pound of nitrogen, of available phosphoric acid and of potash in the several grades. The next table shows this, including the average, lowest and highest costs as well as the retail cash cost of these ingredients in Boston or New York, or, in other words, their "valuations." (See pages 67-69 this bulletin, and pages 81-86, bulletin 99).

COST OF A POUND OF PLANT FOOD IN FERTILIZERS OF VARIOUS GRADES

	NITROGEN			AVAILABLE PHOSPHORIC ACID			POTASH		
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
					cts.				
Low grade,	36.5	41.0	31.6	8.5	10.0	7.4	7.6	8.9	6.5
Medium grade,	30.3	35.3	26.2	7.1	8.2	6.1	6.3	7.3	5.4
High grade,	27.9	30.5	23.6	6.5	7.1	5.5	5.8	6.3	4.9
Retail cost, Boston or New York,	20.5	....	....	4.78	...	...	4.25	...	...

The same lesson enforced in a different way, that cheap fertilizers are the most costly. Some Vermont buyers paid 41 cents for a pound of nitrogen which they might have bought for 24 cents laid down at their doors in mixed fertilizers. They paid under similar circumstances 10 cents a pound instead of 5½ cents for phosphoric acid and 9 cents for potash instead of 5 cents. They paid almost double prices because they did not give the matter attention, or, perhaps, because they did not believe in "book farming." The thoughtful buyer of high class goods, sold at not overhigh prices, bought plant food at figures not much in advance of valuations plus freight rates.

It ought to be said in this connection that the same brands similarly named, in different localities, as well as the same goods variously named in one locality or, indeed, in one dealer's hands, are sometimes found to sell at very different prices, and, apparently, without good reason. A few very exorbitant charges have been noted. Moreover purchasers often fail to exercise good judgment in their choices and pay overhigh charges owing to lack of information as to what to buy and how to buy it. That this situation is largely their own fault can justly be claimed, since the State has thrown about this trade safeguards which are lacking with almost every other class of traffic. The yearly fertilizer inspection, the publication of the results of the work, the free distribution of the bulletins, the clear and concise statements as to the brands on sale, the simplicity and directness of the few fundamental facts which are the main guides as to choice and to purchase; all these are ample justification of the statement that, speaking in general terms, he who is dissatisfied with the results attained with fertilizers has himself to thank for it. This dissatisfaction may be due to unwise choice, the purchase of a goods ill-adapted to a specific purpose; or, it may arise from the realization that one has paid an unreasonably high price in view of the grade of the goods. In either case a repetition of the experience may be avoided by the exercise of a little care as to choice. Particularly in the matter of purchase there often appears to be but little relation between price and plant food content. Thus, for example, goods guaranteed to carry uniform available phosphoric acid contents, but the highly variable nitrogen and potash contents noted below were found selling at a uniform price at points where freight rates were not materially unlike:

Nitrogen, 33 lbs.;	potash, 40 lbs.;	nitrogen and potash, 73 lbs.
Nitrogen, 41 lbs.;	potash, 30 lbs.;	nitrogen and potash, 71 lbs.
Nitrogen, 16 lbs.;	potash, 80 lbs.;	nitrogen and potash, 96 lbs.
Nitrogen, 41 lbs.;	potash, 60 lbs.;	nitrogen and potash, 101 lbs.

A common situation all over the State this year is the sale at a flat price of two brands of the same make with identical nitrogen and phosphoric acid guaranties but with different potash guaranties (1.5 and 3 percents). That is to say a local agent will offer a corn fertilizer at $30 and a potato phosphate at $30, each containing equal amounts of nitrogen and phosphoric acid, but the latter twice as much potash as the former. This is no sin; neither is it against the law. But what well-informed buyer would choose the corn goods in preference to the potato brand?

Identical but differently named goods were sometimes sold by one and the same agent at different prices. Again, two brands with similar nitrogen and phosphoric acid guaranties but different potash figures were sold by the same agent at different prices, the higher price being asked for the lower guarantied goods.

The non-nitrogenous brands, nine of which are licensed, being relatively cheap are quite popular and somewhat widely sold. As a class they carry costly plant food. As sold this year in this State they average to offer 55 cents' worth of plant food for a dollar. When one has ample home supplies of nitrogen they may prove advisable purchases; but commercially they are expensive plant food. As found on sale this year they have proved as a class very irregular in composition and sometimes quite deficient in either phosphoric acid or potash.

3. AS BETWEEN MANUFACTURERS

One company averaged to charge 30 cents for placing a dollar's worth of plant food in the buyer's hands. Yet another asked 70 cents for the same service. In the one case a dollar bought 77 cents' worth of plant food, in the other 59 cents' worth. Two companies for certain brands asked over a dollar to lay down a dollar's worth of plant food at the buyer's depot; or stating it another way, the buyer of their low priced brands paid $2.04 to $2.08 and received a dollar's worth of plant food. His neighbor paid $1.15 for a dollar's worth. Which made the wiser purchase? It is not difficult for anyone to apply this test before purchase. Thus, for example: Selling price, $30; guaranty, nitrogen 2%; soluble, reverted and insoluble phosphoric acids, 6, 3 and 1%s; potash, 3%; $2 \times 20 \times .205 = 8.20$.[1] $6 \times 20 \times .05 = 6.00$. $3 \times 20 \times .045 = 2.70$. $1 \times 20 \times .02 = 0.40$. $3 \times 20 \times .0425 = 2.55$. $8.20 + 6.00 + 2.70 + 0.40 + 2.55 = 19.85$. $19.85 \div 30 = .66$[2]; or $30 \div 19.85 = 1.52$.[3] Fifty-two cents service charge for a dollar's worth of plant food. Sixty-six cents' worth of plant food for a dollar spent.

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[1] I. E. 2% (or 2 lbs. per 100) nitrogen, multiplied by 20 hundreds in a ton, multiplied by the trade value of a pound of nitrogen $0.205, equals the valuation of the guaranty of nitrogen, $8.20. The other calculations are similar.

[2] Valuation divided by cost equals worth of plant food per dollar spent.

[3] Cost divided by valuation indicates service charge paid for a dollar's worth of plant food bought.

V. ANALYSES OF LICENSED FERTILIZERS[1]

AMERICAN AGRICULTURAL CHEMICAL CO., New York, N. Y.

G 2. *Grass and Lawn Top Dressing;* St. Johnsbury.

G 1. *High Grade Ten Percent;* Groton.

(H. J. Baker & Co. Works.)

E 1. *Harvest Home Fertilizer;* Ferrisburgh.

(Bradley Fertilizer Co. Works.)

H9, H23 *Alkaline Bone and Potash;* Bethel, Bennington.

G 3. *Complete Manure for Potatoes and Vegetables;* West Brattleboro.

F 9. *Complete Manure with Ten Percent Potash;* Chester.

F11. *Potato Manure;* Westminster.

F10. *XL Superphosphate of Lime;* Waterbury.

(Clark's Cove Fertilizer Co. Branch.)

G 4. *Potato Fertilizer;* Bethel.

(Cleveland Dryer Co. Works.)

E 2. *Fertilizer for All Crops;* Williamstown.

(Crocker Fertilizer & Chemical Co. Branch.)

H10, H24. *Grass and Oats Fertilizer;* Richmond, Johnson.

E 3. *New Rival Ammoniated Bone Superphosphate;* Ira.

(Great Eastern Fertilizer Co. Branch.)

E 7. *Garden Special;* Windsor.

E 6. *General Fertilizer;* St. Johnsbury.

H11, H25, H26. *Grass and Oats Fertilizer;* Middlebury, Richmond, Richford.

(Quinnipiac Co. Branch.)

G11. *Market Garden Manure;* Brattleboro.

(Read Fertilizer Co. Works.)

E16. *High Grade Farmers' Friend Superphosphate;* Roxbury.

E15. *Standard Superphosphate;* South Northfield.

H14. *Sure Catch Phosphate;* Sudbury.

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[1] The descriptions of samples, the analyses of which were first printed in bulletin 134, occur therein and are not repeated here.

(*H. F. Tucker Co. Branch.*)

F16. *Imperial Bone Superphosphate for All Crops;* Jonesville.

(*Williams & Clark Fertilizer Co. Works.*)

D10. *Americus Potato Manure;* Brattleboro.

G12. *Americus Potato Phosphate;* Morrisville.

G13. *Prolific Crop Producer;* Sheldon Junction.

BOWKER FERTILIZER Co., 43 Chatham St., Boston, Mass.

H 6. *Early Potato Manure;* South Barre.

F12. *Hill and Drill Phosphate;* Groton.

F 8. *Market Garden Fertilizer;* Northfield.

F 1. *Potash Bone;* Enosburg Falls.

F 3. *Potash or Staple Phosphate;* Northfield.

F 5. *Potato and Vegetable Fertilizer;* Barton.

F 7. *Square Brand Bone and Potash;* Williamstown.

F 6. *Stockbridge Manure for Potatoes;* Northfield.

H16. *Stockbridge Manure for Topdressing Grass;* Marshfield.

G16, H18. *Stockbridge Manure for Corn and Grain;* Northfield, Bristol.

H13. *Superphosphate with Potash;* Richmond.

F 1. *Sure Crop Phosphate;* Groton.

COE-MORTIMER Co., 24-26 Stone St., New York, N. Y.

E 4. *Gold Brand Excelsior Guano;* Montpelier.

E 5. *High Grade Ammoniated Bone Superphosphate;* Hartland.

G 5. *New Englander Corn Fertilizer;* Dorset.

H15, H27. *Prize Brand Grass and Grain;* Dorset, Newport.

ESSEX FERTILIZER Co., 39 North Market St., Boston, Mass.

H17. *Complete Manure for Corn, Grain and Grass;* Vergennes.

F12. *Complete Manure for Potatoes, Roots and Vegetables;* Putney.

F13. *Grass and Grain Fertilizer;* Putney.

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

H12. *Animal Bone and Potash No. 2;* Bradford.

G 8. *G Brand;* Plainfield.

G 9. *Grass and Oats Fertilizer;* East Berkshire.

E 8. *Oneida Special;* Plainfield.

G10. *Special Corn Fertilizer;* Ludlow.
G 7. *Special Potato Fertilizer;* Ludlow.
E 9. *Special Ten Percent Potato Fertilizer;* St. Albans.

LOWELL FERTILIZER Co., 40 North Market St., Boston, Mass.

E12. *Bone Fertilizer for Corn and Grain;* Burlington.
G 6. *Cereal Fertilizer;* Enosburg Falls.
E10. *Empress Brand;* Montpelier.
H 5. *Potato Phosphate;* Johnson.
E11. *Superior Fertilizer;* Burlington.

NEW ENGLAND FERTILIZER Co., 42 North Market St., Boston, Mass.

E14. *Corn Phosphate;* Cambridge.
C13. *Peerless Fertilizer;* Concord.
E13. *High Grade Ten Percent Fertilizer;* Montpelier.

PARMENTER & POLSEY FERTILIZER Co., 40 B North Market St., Boston, Mass.

H 1. *Aroostook Special;* Springfield.
H19. *Grain Grower Brand;* Williamstown.
F14. *Plymouth Rock;* Springfield.
H 4. *Potato Fertilizer;* Springfield.
H 2. *Potato Grower;* Springfield.
H 3. *Special Potato Fertilizer;* Rockingham.
F15. *Star Brand Superphosphate;* Springfield.

ROGERS & HUBBARD Co., Middletown, Conn.

H 8. *Grass and Grain Fertilizer;* Springfield.
G14. *Oats and Top Dressing;* Swanton.
G15. *Soluble Potato Manure;* Barre.
H 7. *Soluble Tobacco Manure;* Springfield.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
G 2	A. A. C. Co. Grass & Lawn Top Dress.	5.37	0.03	5.40	*3.91*	19.99	1.30	5.60	1.42	8.32	*6.*	6.90	*5.*	$6.91	†4.49	*2.*	$3.96
G 1	A. A. C. Co. High Grade Ten Percent	0.88	1.49	2.37	*2.4*	9.37	3.62	2.38	2.20	8.20	*7.*	6.00	*6.*	6.64	9.88	*10.*	8.40
D 11	A. A. C. Co. Baker's Complete Potato	1.68	1.76	3.44	*3.3*	13.44	3.48	2.88	2.08	8.44	*7.*	6.36	*6.*	6.90	9.87	*10.*	8.39
E 1	A. A. C. Co. Baker's Harvest Home...	......	1.12	1.12	*1.03*	4.59	4.02	4.06	2.64	10.72	*10.*	8.08	*8.*	8.72	2.00	*2.*	1.70
C 1	A. A. C. Co. Baker's Standard UnXLD	0.60	0.91	1.51	*1.65*	5.95	5.24	2.80	2.40	10.44	*10.*	8.04	*8.*	8.72	2.24	*2.*	1.90
*H 9 H 23	A. A. C. Co. Bradley's Alk. Bo. & Pot.	......	......	......	......	......	4.49	5.83	2.96	13.28	*12.*	10.32	*11.*	10.92	1.91	*2.*	1.62
G 3	A. A. C. Co. Bradley's Com. Pot. Veg.	(A) 1.68	1.81	3.49	*3.3*	13.38	5.76	2.92	2.12	10.80	*9.*	8.68	*8.*	9.24	6.73	*7.*	5.72
F 9	A. A. C. Co. Bradley's Ten % Potash	1.65	1.82	3.47	*3.3*	13.57	4.26	2.52	1.86	8.64	*7.*	6.78	*6.*	7.27	10.25	*10.*	8.70
A 5	A. A. C. Co. Bradley's Corn Phos......	0.62	1.55	2.17	*2.06*	8.65	5.06	3.30	2.68	11.04	*10.*	8.36	*8.*	9.10	1.90	*1.5*	1.62
C 4	A. A. C. Co. Bradley's Eclipse Phos...	0.27	0.63	0.90	*1.03*	3.60	5.32	3.98	2.46	11.76	*10.*	9.30	*8.*	9.88	2.12	*2.*	1.80
C 3	A. A. C. Co. Bradley's Niagara Phos..	......	1.12	1.12	*0.82*	4.59	3.74	4.24	2.98	10.96	*8.*	7.98	*7.*	8.76	1.45	*1.*	1.23
A 6	A. A. C. Co. Bradley's Potato Fert....	0.46	1.52	1.98	*2.06*	7.93	5.02	3.28	2.82	11.12	*10.*	8.30	*8.*	9.10	3.36	*3.*	2.86

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. †Potash partly as sulphate.
(A) 0.40% as nitrate; 1.28% as ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen†	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid†	Found	Guaranteed	Valuation of Potash†
										Found	Guar.	Found	Guar.				
F 11	A. A. C. Co. Bradley's Potato Manure	0.98	1.85	2.83	*2.5*	$ 11.21	4.24	2.64	2.32	9.20	*8.*	6.88	*6.*	$ 7.55	6.78	*5.*	$5.76
A 4	A. A. C. Co. Bradley's Vermonter......	0.67	1.54	2.21	*2.06*	8.79	4.84	3.34	2 72	10.90	*10.*	8.18	*8.*	8.94	3.11	*3.*	2.64
F 10	A. A. C. Co. Bradley's XL Superphos.	1.21	1.74	2.95	*2.5*	11.61	6.92	2.16	1.96	11.04	*11.*	9.08	*9.*	9.64	2.71	*2.*	2.30
C 6	A. A.C. Co. Clark's Cove Bay St. G. G.	0.70	1.44	2.14	*2.06*	8.49	5.74	2.64	2.90	11.28	*10.*	8.38	*8.*	9.28	1.65	*1.5*	1.40
B 10	A. A. C. Co. Clark's Cove King Philip	......	1.26	1.26	*1.03*	5.17	5.18	3.20	2.14	10.52	*10.*	8.38	*8.*	8.92	2.06	*2.*	1.75
G 4	A. A. C. Co. Clark's Cove Potato Fert.	0.76	1.34	2.10	*2.06*	8.31	5.96	2.60	2.26	10.82	*10.*	8.56	*8.*	9.20	3.50	*3.*	2.98
E 2	A. A. C. Co. Cleveland Fert. All Crops	......	1.37	1.37	*1.03*	5.62	5.40	3.38	2.10	10.88	*10.*	8.78	*8.*	9.28	2.20	*2.*	1.87
B 11	A. A. C. Co. Cleveland Potato Phos...	0.77	1.37	2.14	*2.06*	8.47	5.32	2.94	2.62	10.88	*10.*	8.26	*8.*	9 02	3.21	*3.*	2.73
C 5	A. A. C. Co. Cleveland Superphos......	0.77	1.40	2.17	*2.06*	8.59	5.50	2.58	2.68	10.76	*10.*	8.08	*8.*	8.89	1.92	*1.5*	1.63
A 8	A. A. C. Co. Crocker's Am. Corn Phos.	0.55	1.46	2.01	*2.06*	8.03	5.46	2.68	2.44	10.58	*10.*	8.14	*8.*	8.84	2.25	*1.5*	1.91
H 10 H 24	A. A. C. Co. Crocker's Grass & Oats Fert.	......	......	......	......	......	4.60	5.95	3.25	13.80	*12.*	10.55	*11.*	11.25	2.05	*2.*	1.74

*Potash in brands thus marked is largely if not entirely in form of sulphate. †See definition, page

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
H 20	A. A. C. Co. Crocker's H. G. Special..	¶0.28	1.42	1.70	1.65	$6.80	6.02	2.72	2.12	10.86	9.	8.74	8.	$9.32	4.57	4.	$3.88
H 21	A. A. C. Co. Crocker's N. Y. Special..	......	......	......	......	......	8.58	2.44	1.70	12.72	11.	11.02	10.	11.46	7.99	8.	6.79
E 3	A. A. C. Co. Crocker's New Rival......	......	1.16	1.16	1.03	4.76	5.06	3.76	1.86	10.68	10.	8.82	8.	9.18	2.05	2.	1.74
A 9	A. A. C.Co.Crocker's Pot., Hop & Tob.	0.67	1.38	2.05	2.06	8.13	4.16	3.52	3.25	10.93	10.	7.68	8.	8.63	3.22	3.	2.74
C 8	A. A. C. Co. Crocker's Potato Special	1.61	1.72	3.33	3.3	13.01	3.68	2.40	1.52	7.60	7.	6.08	6.	6.45	10.44	10.	8.88
C 9	A. A. C. Co. Cumberland Potato Fert.	0.63	1.32	1.95	2.06	7.74	6.18	2.48	2.22	10.88	10.	8.66	8.	9.30	3.78	3.	3.21
C 10	A. A. C. Co. Cumberland Superphos.	0.84	1.30	2.14	2.06	8.44	4.17	3.81	3.32	11.30	10.	7.98	8.	8.93	1.82	1.5	1.55
D 16	A. A. C. Co. Darling's Farm Favorite	0.86	1.19	2.05	2.06	8.07	3.78	4.18	3.24	11.20	10.	7.96	8.	8.84	3.01	2.	2.56
D 15	A. A. C. Co. Darling's Potato Manure	1.00	1.67	2.67	2.5	10.53	5.00	2.24	2.16	9.40	8.	7.24	6.	7.88	5.83	5.	4.96
E 7	A. A. C. Co. Gr. East. Garden Spec....	1.60	2.05	3.65	3.3	14.33	5.82	2.36	1.66	9.84	9.	8.18	8.	8.60	7.26	7.	6.17
E 6	A. A. C. Co. Gr. Eastern General	......	1.44	1.44	0.82	5.90	4.82	2.88	2.74	10.44	10.	7.70	8.	8.51	5.09	4.	4.33
H 11 H 25 H 26	A.A.C.Co. Gr. East. Grass & Oats Fert.	......	......	......	.....	......	4.16	6.29	3.13	13.58	12.	10.45	11.	11.00	1.99	2.	1.82

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. ¶ As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
A 12	A. A. C. Co. Gr. East. Nor. Corn Spec.	0.83	1.38	2.21	*2.06*	$ 8.73	5.98	2.42	2.84	11.24	*10.*	8.40	*8.*	$9.29	1.89	*1.5*	$1.61
A 13	A. A. C. Co. Gr. East. Potato Manure	0.78	1.39	2.17	*2.06*	8.59	5.16	3.04	2.36	10.56	*10.*	8.20	*8.*	8.85	3.20	*3.*	2.72
C 16	A. A. C. Co. Pac. Gu. Co. Nobsque Gu.	......	1.37	1.37	*1.03*	5.62	5.80	2.94	2.30	11.04	*10.*	8.74	*8.*	9.37	2.02	*2.*	1.72
A 16	A. A. C. Co. Pac. Gu. Co. Potato Spec.	0.67	1.40	2.07	*2.06*	8.22	5.40	2.88	2.42	10.70	*10.*	8.28	*8.*	8.96	3.22	*3.*	2.74
B 1	A. A. C. Co. Pac. Gu. Co. Sol. Pac. Gu	0.63	1.51	2.14	*2.06*	8.52	5.92	2.78	2.42	11.12	*10.*	8.70	*8.*	9.39	1.98	*1.5*	1.68
C 15	A. A. C. Co. Quinnipiac Climax Phos.	......	1.37	1.37	*1.03*	5.62	5.34	3.50	2.28	11.12	*10.*	8.84	*8.*	9.40	1.99	*2.*	1.69
B 3	A. A. C. Co. Quinnipiac Corn Manure	0.67	1.38	2.05	*2.06*	8.14	6.02	2.16	3.02	11.20	*10.*	8.18	*8.*	9.17	2.08	*1.5*	1.77
G 11	A. A. C. Co. Quinnipiac Market Gard.	1.53	1.87	3.40	*3.3*	13.33	5.74	2.29	1.75	9.78	*9.*	8.03	*8.*	8 50	6.96	7.	5.92
B 2	A. A. C. Co. Quinnipiac Potato Phos.	0.74	1.33	2.07	*2.06*	8.19	5.32	3.18	2.50	11.00	*10.*	8.50	*8.*	9.18	3.28	*3.*	2.79
B 4	A. A. C. Co. Read's Farmer's Friend.	0.35	1.46	1.81	*2.06*	7.28	3.98	4.32	2.66	10.96	*10.*	8.30	*8.*	8.93	3.62	*3.*	3.08
E 16	A. A. C. Co. Read's H. G. F. Friend.	1.53	1.59	3.12	*3.3*	12.18	3.26	3.04	1.94	8.24	*7.*	6.30	*6.*	6.78	10.47	*10.*	8.90
B 5	A. A. C. Co. Read's Leader Blo. & Bo.	......	1.19	1.19	*0.82*	4.88	4.48	3.80	3.08	11.36	*8.*	8.28	7.	9.13	1.32	*1.*	1.12

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
D 6	A. A. C. Co. Read's Prac. Potato Spec.	......	1.51	1.51	*0.82*	$6.19	4.96	2.28	2.02	9.26	*5.*	7.24	*4.*	$7.82	10.03	*8.*	$8.53
E 15	A. A. C. Co. Read's Standard Superph.	.....	1.47	1.47	*0.82*	6.03	4.98	2.69	2.81	10.48	*10.*	7.67	*8.*	8.52	5.07	*4.*	4.31
H 14	A. A. C. Co. Read's Sure Catch Phos.	......	......	......	......	......	5.44	4.62	3.46	13.52	*11.*	10.06	*10.*	10.98	1.57	*2.*	1.33
F 16	A. A. C. Co. Tucker's Imp. for all Crops	0.37	0.70	1.07	*1.03*	4.24	6.66	3.00	2.10	11.76	*10.*	9.66	*8.*	10.20	2.22	*2.*	1.89
B 8	A. A. C. Co. Tucker's Imp. for Corn..	......	0.88	0.88	*1.03*	3.60	5.76	3.80	2.28	11.84	*10.*	9.56	*8.*	10.09	2.17	*2.*	1.84
D 7	A. A. C. Co. Tucker's Imp. for Potatoes	......	1.12	1.12	*1.03*	4.59	4.82	4.88	2.46	12.16	*10.*	9.70	*8.*	10.18	2.31	*2.*	1.96
D 8	A. A. C. Co. W. & C. Co.'s Am. Corn Phos.	0.88	1.08	1.96	*2.06*	7.69	5.00	3.48	3.00	11.48	*10.*	8.48	*8.*	9.33	1.79	*1.5*	1.52
B 9	A. A. C. Co. W. & C. Co.'s H. G. Spec.	1.33	2.11	3.44	*3.3*	13.57	4.98	3.03	1.65	9.66	*9.*	8.01	*8.*	8.37	7.26	*7.*	6.17
D 10	A. A. C. Co. W. & C. Co.'s Potato Man.	0.81	1.29	2.10	*2.06*	8.29	5.46	2.70	2.12	10.28	*10.*	8.16	*8.*	8.74	3.15	*3.*	2.68
G 12	A. A. C. Co. W. & C. Co.'s Pot. Phos.	1.06	1.68	2.74	*2.5*	10.81	4.88	2.40	2.08	9.36	*8.*	7.28	*6.*	7.87	5.60	*5.*	4.76
G 13	A. A. C. Co. W. & C. Co.'s Prol. Crop Prod.	......	1.37	1.37	*0.82*	5.62	4.20	3.94	2.84	10.98	*8.*	8.14	*7.*	8.89	1.25	*1.*	1.06
D 9	A. A. C. Co. W. & C. Co.'s Roy. Bone	......	1.33	1.33	*1.03*	5.45	5.14	3.66	2.24	11.04	*10.*	8.80	*8.*	9.33	1.95	*2.*	1.67

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
A 2	Bowker's Corn Phosphate.................	0.41	1.20	1.61	*1.65*	$6.44	6.08	2.46	2.16	10.70	*9.*	8.54	*8.*	$9.15	2.15	*2.*	$1.83
H 6	Bowker's Early Potato Manure.........	(A) 1.44	2.14	3.58	*3.29*	13.85	4.88	3.40	2.36	10.64	*10.*	8.28	*8.*	8.89	6.70	*7.*	5.70
F 2	Bowker's Hill and Drill Phosphate....	1.16	1.70	2.86	*2.47*	11.26	6.76	2.68	1.76	11.20	*10.*	9.44	*9.*	9.87	2.68	*2.*	2.28
F 8	Bowker's Market Garden Fertilizer...	0.37	2.40	2.77	*2.47*	11.21	4.00	2.66	2.82	9.48	*7.*	6.66	*6.*	7.52	9.85	*10.*	8.37
F 1	Bowker's Potash Bone.........	......	1.12	1.12	*0.82*	4.59	6.38	2.38	2.32	11.08	*7.*	8.76	*6.*	9.45	1.93	*2.*	1.64
F 3	Bowker's Potash or StaplePhosphate	0.48	0.82	1.30	*0.82*	5.14	5.82	3.16	2.42	11.40	*9.*	8.98	*8.*	9.63	3.58	*3.*	3.04
F 5	Bowker's Potato and Vegetable Fert..	0.91	1.41	2.32	*2.47*	9.15	4.54	3.88	2.62	11.04	*9.*	8.42	*8.*	9.08	4.57	*4.*	3.88
A 3	Bowker's Potato and Vegetable Phos.	0.60	1.05	1.65	*1.65*	6.53	5.88	2.82	2.20	10.90	*10.*	8.70	*8.*	9.30	2.19	*2.*	1.86
F 7	Bowker's Square Brand Bone and Pot.	0.63	1.46	2.09	*1.65*	8.32	5.36	2.86	2.42	10.64	*7.*	8.22	*6.*	8.90	2.33	*2.*	1.98
G 16 } H 18 }	Bowker's Stockbridge Corn and Grain	(B) 1.53	2.02	3.55	*3.29*	13.85	5.64	2.64	2.18	10.46	*11.*	8.28	*10.*	8.89	7.01	*7.*	5.96
F 6	Bowker's Stockbridge Potato Manure	1.49	1.75	3.24	*3.29*	12.69	2.78	3.36	2.14	8.28	*7.*	6.14	*6.*	6.66	10.27	*10.*	8.72
H 16	Bowker's Stockbridge Top Dressing	(C) 3.25	1.66	4.91	*4.93*	18.65	2.22	2.22	2.40	6.84	*6.*	4.44	*4.*	5.18	7.85	*6.*	6.67

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. (A) 0.18 percent as nitrate, 1.26 percent as ammonia salts. (B) 1.07 percent as nitrate, 0.46 percent as ammonia salts. (C) 2.32 percent as nitrate, 0.98 percent as ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
H 13	Bowker's Superphos. with Potash......	......	......	......	......	$	5.08	4.85	3.69	13.62	*11.*	9.93	*10.*	$ 10.92	1.50	*2.*	$1.28
F 4	Bowker's Sure Crop Phosphate.........	......	1.16	1.16	*0.82*	4.76	6.52	2.54	2.30	11.36	*9.*	9.06	*8.*	9.73	2.02	*2.*	1.72
A 1	Bowker's Vt. Grange Chem. D. Brand	0.67	1.50	2.17	*2.06*	8.63	5.32	2.70	2.50	10.52	*9.*	8.02	*8.*	8.75	3.05	*3.*	2.59
¶B 15	Buffalo Fert. Co.'s Celery & Pot. Spec.	§0.25	1.43	1.68	*1.64*	6.64	3.48	4.23	2.05	9.76	*9.*	7.71	*8.*	8.11	10.45	*10.*	8.88
B 13	Buffalo Fert. Co.'s Farmer's Choice...	§0.42	0.67	1.09	*0.82*	4.22	4.19	4.29	1.92	10.40	*9.*	8.48	*8.*	8.81	5.02	*5.*	4.27
B 12	Buffalo Fert. Co.'s Fish Guano.........	§0.46	0.80	1.26	*0.82*	4.89	4.52	4.76	2.24	11.52	*10.*	9.28	*9.*	9.70	3.25	*2.*	2.76
B 16	Buffalo Fert. Co.'s General Crop........	......	......	......	......	.....	6.73	4.04	2.13	12.90	*11.*	10.77	*9.*	11.22	5.15	*3.*	4.38
**B 14	Buffalo Fert. Co.'s Ideal Wheat & Corn	§0.40	1.53	1.93	*1.64*	7.67	4.02	4.50	2.45	10.97	*10.*	8.52	*9.*	9.05	4.59	*5.*	3.90
¶¶D 12	Buffalo Fert. Co.'s Vegetable & Potato	§0.51	1.52	2.03	*2.45*	8.02	2.90	4.80	2.48	10.18	*9.*	7.70	*8.*	8.22	5.93	*7.*	5.03
D 13	Burl. Rend. Co.'s Animal Fertilizer...	......	2.95	2.95	*2.*	12.10	0.14	5.18	2.68	8.00	*7.*	5.32	*4.*	5.87	4.50	*4.*	3.83
D 14	Burl. Rend. Co.'s Special Potato......	......	2.95	2.95	*2.47*	12.10	0.16	4.90	3.70	8.76	*8.*	5.06	*5.*	6.05	7.34	*6.*	6.24

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*Potash in brands thus marked is largely if not entirely in form of sulphate. §As ammonia salts. ‡See definition, page 69.

¶Another and very unlike sample carried 1% excess nitrogen and 3.5% deficiency in potash, but an equivalent in commercial value of its guaranty. The manufacturers suggest shipment of Vegetable and Potato goods through error.

**Another sample guaranteed 8% available phosphoric acid instead of 9% met its lowered guaranty.

¶¶See statement on pages 71-72.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen: From Nitrates	Nitrogen: From Organic Matter	Nitrogen: Total Found	Nitrogen: Total Guaranteed	Nitrogen: Valuation of Nitrogen‡	Phosphoric Acid: Soluble	Phosphoric Acid: Reverted	Phosphoric Acid: Insoluble	Phosphoric Acid: Total: Found	Phosphoric Acid: Total: Guar.	Phosphoric Acid: Available: Found	Phosphoric Acid: Available: Guar.	Phosphoric Acid: Valuation of Phosphoric Acid‡	Potash: Found	Potash: Guaranteed	Potash: Valuation of Potash‡
††A 7	Coe-Mort. Co.'s Col. Corn & Potato...	§0.25	1.01	1.26	*1.23*	$5.02	3.15	4.90	1.86	9.91	*10.5*	8.05	*8.5*	$8.31	2.43	*2.5*	$2.07
E 4	Coe-Mort. Co's Gold Brand Exc. Gua.	......	2.42	2.42	*2.4*	9.93	3.81	4.24	1.51	9.56	*10.*	8.05	*8.*	8.23	5.67	*6.*	4.82
E 5	Coe-Mort. Co's High Gd. Ammo. Bone	......	2.03	2.03	*1.85*	8.32	5.22	4.52	1.94	11.68	*11.*	9.74	*9.*	10.06	2.84	*2.25*	2.41
G 5	Coe-Mort. Co's New Eng. Corn Fert...	§0.29	1.11	1.40	*0.8*	5.57	4.06	5.30	1.60	10.96	*9.*	9.36	*7.5*	9.47	3.05	*3.*	2.59
†C 7	Coe-Mort. Co's New Eng. Potato Fert...	......	0.98	0.98	*0.8*	4.02	4.14	4.14	1.88	10.16	*9.*	8.28	*7.5*	8.62	2.62	*3.*	2.23
H15 H27	Coe-Mort. Co's Prize Brand Grass & Gr.	......	......	......	......	......	5.21	5.97	2.23	13.41	*12.*	11.18	*10.*	11.47	1.64	*2.*	1.40
A 11	Essex Fert. Co.'s A 1 Superphosphate	......	1.14	1.14	*1.2*	4.67	6.72	1.70	1.02	9.44	*8.*	8.42	*7.*	8.66	2.13	*2.*	1.81
H 17	Essex Fert. Co.'s Corn, Grain, Grass..	§1.18	1.95	3.13	*3.28*	12.13	2.44	3.66	4.98	11.08	*7.*	6.10	*6.*	7.73	10.44	*10.*	8.87
F 12	Essex Fert. Co.'s Potato, Root, Veg..	(A) 0.88	2.56	3.44	*3.25*	13.66	2.02	3.56	4.50	10.08	*7.*	5.58	*6.*	7.02	10.80	*10.*	9.18
F 13	Essex Fert. Co.'s Grass & Grain Fert.	......	1.02	1.02	*0.82*	4.18	6.92	2.16	0.72	9.80	*9.*	9.08	*8.*	9.15	4.46	*4.*	3.79
D 1	Essex Fert. Co.'s Market Gar. & Pot.	......	1.98	1.98	*2.*	8.12	3.42	4.51	5.01	12.94	*9.*	7.93	*8.*	9.48	5.55	*5.*	4.72
A 10	Essex Fert. Co.'s XXX Fish & Potash	......	2.10	2.10	*2.*	8.61	7.06	2.08	1.78	10.92	*9.*	9.14	*8.*	9.64	3.04	*3.*	2.59

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. §As ammonia salts.

††This sample is a composite of two lots, one a half percent low in potash, the other a percent low in available phosphoric acid, each a few cents short of making good the commercial equivalent of the guaranty.

†The potash contents of the two samples used in making C7 were 2.80 and 2.96 percents. A third sample carried 3.84%.

(A) 0.40 percent as nitrate, 0.48 percent as ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
H 12	Lister's Animal Bone & Potash No. 2	......	......	......	......	$	5.38	4.76	1.46	11.60	*11.*	10.14	*10.*	$ 10.24	2.17	*2.*	$1.84
G 8	Lister's G. Brand	......	0.98	0.98	*0.82*	4.02	5.04	3.12	0.92	9.08	*10.*	8.16	*8.*	8.22	3.94	*4.*	3.35
G 9	Lister's Grass and Oats Fert.	......	0.95	0.95	*0.82*	3.90	5.14	2.91	0.93	8.98	......	8.05	*8.*	8.13	3.70	*4.*	3.15
E 8	Lister's Oneida Special	......	0.98	0.98	*0.83*	4.02	3.24	4.10	2.06	9.40	*8.*	7.34	*7.*	7.75	1.33	*1.*	1.13
D 2	Lister's Potato Manure	§1.69	1.92	3.61	*3.3*	13.79	5.70	3.05	0.88	9.63	*9.*	8.75	*8.*	8.79	7.26	*7.*	6.17
G 10	Lister's Special Corn Fertilizer	......	1.79	1.79	*1.65*	7.34	4.36	4.19	2.91	11.46	*9.*	8.55	*8.*	9.29	3.49	*3.*	2.97
G 7	Lister's Special Potato Fertilizer	......	1.89	1.89	*1.65*	7.75	4.53	4.54	2.21	11.28	*9.*	9.07	*8.*	9.50	3.35	*3.*	2.85
E 9	Lister's Special Ten Percent Potato	......	1.79	1.79	*1.65*	7.34	7.94	1.86	0.76	10.56	*9.*	9.80	*8.*	9.91	10.41	*10.*	8.85
A 14	Lister's Success Fertilizer	......	1.30	1.30	*1.24*	5.33	6.54	2.88	1.86	11.28	*11.*	9.42	*9.*	9.87	2.24	*2.*	1.90
A 15	Lowell (Swift's) Animal Brand	......	2.46	2.46	*2.46*	10.09	5.48	2.84	1.94	10.28	*10.*	8.32	*8.*	8.83	4.15	*4.*	3.53
E 12	Lowell (Swift's) Bone Fert. Corn & Gr.	......	1.72	1.72	*1.64*	7.05	5.60	2.84	1.56	10.00	*9.*	8.44	*8.*	8.78	3.26	*3.*	2.77
G 6	Lowell (Swift's) Cereal Fertilizer	......	1.02	1.02	*0.82*	4.18	3.14	4.18	1.32	8.64	*8.*	7.32	*7.*	7.43	1.57	*1.*	1.33

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
E 10	Lowell (Swift's) Empress Brand........	......	1.37	1.37	*1.23*	$5.62	4.44	2.90	1.54	8.88	*8.*	7.34	*7.*	$ 7.66	2.23	*2.*	$1.90
D 4	Lowell (Swift's) Potato Manure........	......	1.74	1.74	*1.64*	7.13	4.26	3.52	0.54	8.32	*8.*	7.78	*7.*	7.65	4.08	*4.*	3.47
H 5	Lowell (Swift's) Potato Phosphate....	......	2.70	2.70	*2.46*	11.07	4.68	2.98	1.72	9.38	*9.*	7.66	*8.*	8.04	5.67	*6.*	4.82
D 3	Lowell (Swift's) Sterling Phosphate...	......	1.02	1.02	*0.82*	4.18	4.82	3.39	0.57	8.78	*9.*	8.21	*8.*	8.09	4.06	*4.*	3.46
E 11	Lowell (Swift's) Superior Phosphate..	(A) 0.83	3.03	3.86	*3.69*	15.44	4.32	3.28	1.64	9.24	*8.*	7.60	*7.*	7.92	9.78	*10.*	8.31
C 12	N. E. Fert. Co.'s Corn & Grain Fert...	......	1.23	1.23	*1.23*	5.04	4.54	2.52	1.02	8.08	*8.*	7.06	*7.*	7.22	2.06	*2.*	1.75
E 14	N. E. Fert. Co.'s Corn Phosphate......	0.23	1.61	1.84	*1.64*	7.45	5.54	2.46	1.32	9.32	*9.*	8.00	*8.*	8.28	3.22	*3.*	2.74
C 13	N. E. Fert. Co.'s Peerless..................	......	0.98	0.98	*0.82*	4.02	5.12	1.77	0.67	7.56	*8.*	6.89	*7.*	6 98	1.23	*1.*	1.05
E 13	N. E. Fert. Co.'s High Grade 10%.....	(B) 0.93	2.88	3 81	*3.5*	15.12	3.82	3.22	1.40	8.44	*8.*	7.04	*7.*	7.28	9.95	*10.*	8.46
C 11	N. E. Fert. Co.'s Potato Fertilizer......	......	1.89	1.89	*1.64*	7.75	4.72	2.40	0.92	8.04	*8.*	7.12	*7.*	7.25	4.06	*4.*	3.46
H 1	P. & P. Co.'s Aroostook Special.........	(C) 0.87	2.81	3.68	*3.7*	14.66	4.38	3.10	1.72	9.20	*8.*	7.48	*7.*	7.85	9.74	*10.*	8.28
H 19	P. & P. Co.'s Grain Grower Brand.....	......	1.47	1.47	*1.23*	6 03	4.52	2.80	1.04	8.36	*8.*	7.32	*7.*	7.46	2.36	*2.*	2.00

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡See definition, page 69. §As ammonia salts. (A) 0.56 percent as nitrate, 0.27 percent as ammonia salts. (B) 0.26 percent as nitrate, 0.67 percent as ammonia salts. (C) 0.47 percent

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
F 14	P. & P. Co.'s Plymouth Rock	......	2.49	2.49	*2.47*	$10.21	4.26	3.94	2.68	10.88	*9.*	8.20	*8.*	$8.88	4.32	*4.*	$3.67
H 4	P. & P. Co.'s Potato Fertilizer	......	1.89	1.89	*1.65*	7.75	3.35	2.69	1.40	7.44	*7.*	6.04	*6.*	6.33	4.16	*6.*	3.54
H 2	P. & P. Co.'s Potato Grower	§0.78	1.71	2.49	*2.46*	9.74	4.42	1.84	1.06	7.32	*7.*	6.26	*6.*	6.50	9.69	*10.*	8.24
H 3	P. & P. Co.'s Special Potato	0.93	2.25	3.18	*3.28*	12.67	4.74	5.20	1.38	11.32	*9.*	9.94	*8.*	9.98	7.15	*7.*	6.08
F 15	P. & P. Co.'s Star Brand Superphos.	......	2.24	2.24	*1.65*	9.18	3.40	3.76	0.92	8.08	*8.*	7.16	*7.*	7.15	4.15	*4.*	3.53
D 5	R. & H. Co.'s Complete Phosphate	0.22	0.90	1.12	*1.*	4.51	4.02	4.40	1.42	9.84	*9.*	8.42	*8.*	8.55	4.03	*3.5*	3.43
H 8	R. & H. Co.'s Grass & Grain Fert.	......	3.05	3.05	*2.2*	12.51	0.16	6.96	9.28	16.40	*16.*	7.12	*6.6*	10.13	10.83	*12.*	9.21
G 14	R. & H. Co.'s Oats and Top Dressing.	7.72	0.98	8.70	*8.5*	32.58	0.28	4.55	3.77	8.60	*8.*	4.83	*3.9*	5.89	10.29	*8.*	8.75
B 6	R. & H. Co.'s Potato Phosphate	0.95	1.29	2.24	*2.*	8.81	4.62	4.20	2.70	11.52	*10.*	8.82	*9.*	9.48	6.10	*5.*	5.18
B 7	R. & H. Co.'s Sol. Corn & Gen. Crops	1.12	1.23	2.35	*2.5*	9.18	1.96	4.44	3.20	9.60	*8.*	6.40	*6.*	7.24	9.14	*8.*	7.77
*G 15	R. & H. Co.'s Sol. Potato Manure	(A) 2.86	2.09	4.95	*5.*	19.09	0.30	8.18	4.68	13.16	*10.*	8.48	*7.*	9.53	*6.50	*5.*	6.35
*H 7	R. & H. Co.'s Sol. Tobacco Manure	(B) 2.53	2.02	4.55	*5.*	17.60	0.74	7.30	4.08	12.12	*10.*	8.04	*7.*	8.94	*14.46	*10.*	14.41

*Potash in brands thus marked is largely if not entirely in form of sulphate. ‡Se definition page 69. §As ammonia salts. (A) 2.54 percent as nitrate, 0.32 percent as ammonia salts. (B) 2.30 percent as nitrate. 0.23 percent as ammonia salts.

NOTE.—The slight shortages in the Rogers and Hubbards goods may be explained by the fact that bone goods are more prone to mechanical separation than those made from phosphate rock.

VI. ANALYSES OF FERTILIZERS FOR FIVE YEARS, 1904-1908.

The buyer of mixed goods usually makes his choice before the analyses are published. The Station prints the analyses of about 60 brands early in April, and issues its final bulletin in June. These dates are far in advance of the issuance of similar figures by other northern stations, yet the information they convey often reaches the buyer too late to be of service; and if station analyses are consulted at all, those of former years are used. These may or may not be safe guides. If, however, reference to analyses for successive years shows essential uniformity of composition in the past *and an unchanged guaranty,* the buyer is safe in assuming that the former figures will be applicable. If the guaranty statement has been changed, and if former statements have been lived up to in the past years, the presumption is in favor of similar keeping of promises for the present year.

In order to facilitate such reference and to indicate something of the evenness or variation in composition from year to year of the several brands, tables are given herewith showing the nitrogen, available phosphoric acid and potash percentages for the past five years of the 130 of the 131 licensed brands. The guaranties printed in the tables are those for 1908 as well as for 1904-1907, with a few exceptions, which are foot-noted. The * indicates that sulphate of potash was used as a source of potash, the †, that 0.20 percent or more of nitrogen was present in water-soluble shapes (as nitrate of soda or as sulphate of ammonia).

These tables, containing the essentials of five years' inspection, ought to prove helpful in choosing fertilizers, particularly when they are bought early in the season.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
American Agricultural Chem. Co.'s	Grass and Lawn Top Dres.	†4.90	†5.19	†4.98	†3.82	†5.40	*3.91*	5.34	5.23	6.18	5.50	6.90	*5.*	*2.82	*3.02	3.12	2.85	*4.49	*2.*
	High Grade Ten Percent...	†2.67	†2.67	†2.81	†2.74	†2.37	*2.4*	6.23	6.68	6.14	6.32	6.00	*6.*	11.45	10.40	10.80	10.75	9.88	*10.*
	Baker's Complete Potato ...	†3.44	†3.61	†3.47	†3.37	†3.44	*3 3*	6.61	6.71	6.68	7.34	6.36	*6.*	11.24	10.04	9.12	10.48	9.87	*10.*
	Baker's Harvest Home......	1.23	1.51	1.30	1.30	1.12	*1.03*	8.18	7.94	9.32	8.04	8.08	*8.*	2.10	2.10	2.41	2.00	2.00	*2.*
	Baker's Standard UnXld..	†1.89	†2.50	†2.39	†1.82	†1.51	*1.65*	7.95	7.72	8.14	9.04	8.04	*8.*	2.16	2.26	2.68	2.04	2.24	*2.*
	Bradley's Alkaline Bone....	......	......	......	......	......	......	10.96	10.69	11.26	11 30	10.32	*11.*	2.30	2.17	2.24	2.36	1.91	*2.*
	Bradley's Comp.Pot.& Veg.	†3.53	†3.86	†3.33	†4.00	†3.49	*3.3*	7.62	7.82	8.92	8.20	8.68	*8.*	7.34	6.80	*7.58	7.88	6.73	*7.*
	Bradley's Comp. 10 Perc't..	†3.58	†3.61	†3.40	†3.58	†3.47	*3.3*	6.27	6.78	6.66	6.66	6.78	*6.*	11.06	10.30	10.64	11.24	10.25	*10.*
	Bradley's Corn Phosphate..	†2.32	†2.32	†2 21	†2.14	†2.17	*2.06*	8.05	8.01	8.68	8.52	8.36	*8.*	1.70	2.09	2.00	1.84	1.90	*1.5*
	Bradley's Eclipse Phos......	1.33	1.40	1.23	1.33	†0.90	*1.03*	8.10	7.68	8.58	7.99	9.30	*8.*	2.36	2.36	2.32	2.04	2.12	*2.*
	Bradley's Niagara Phos......	1.19	1.19	1.40	1.23	1.12	*0.82*	6.54	6.77	7.50	7.66	7.98	*7.*	1.38	1.60	1.60	1.31	1.45	*1.*
	Bradley's Potato Fertilizer	†2.28	†2.32	†2.24	†2.10	†1 98	*2.06*	8.48	8.14	8.42	8.14	8.30	*8.*	3.10	3.08	3.48	3 36	3.36	*3.*
	Bradley's Potato Manure...	†2.70	†2.77	†2.74	†2.63	†2.83	*2.5*	6.92	7.58	6.74	7.94	6.88	*6.*	5.40	5.95	5.44	5.40	6.78	*5.*
	Bradley's Vermonter.........	†2.28	†2.24	†2.17	†2.32	†2.21	*2.06*	7.83	7.52	8.20	8.38	8.18	*8.*	3.32	3.24	3.20	3.35	3.11	*3.*
	Bradley's XL Superphos...	†2.54	†2.67	†2.53	†2.70	†2.95	*2.5*	9.19	9.48	9.28	9.00	9.08	*9.*	2.40	2.27	2.44	2.33	2.71	*2.*
	Clark's Cove Bay State G.G.	†2.39	†2.28	†2.17	2.53	†2.14	*2.06*	8.33	9.23	8.42	9.23	8.38	*8.*	1.98	1.84	2.08	1.98	1.65	*1.5*

ANALYSES OF LICENSED FERTILIZERS—1904-1908

American Agricultural Chemical Co.'s

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Clark's Cove King Philip...	1.37	1.23	1.33	1.33	1.26	*1.03*	8.18	8.09	8.94	8.06	8.38	*8.*	2.29	2.27	2.47	2.16	2.06	*2.*
Clark's Cove Potato Fert...	†2.27	†2.21	†2.42	†2.39	†2.10	*2.06*	7.58	8.05	8.84	8.78	8.56	*8.*	3.23	3.34	3.54	3.18	3.50	*3.*
Cleveland Fertilizer..........	1.44	1.33	1.33	1.23	1.37	*1.03*	8.14	8.54	8.44	8.38	8.78	*8.*	2.24	2.67	2.36	2.03	2.20	*2.*
Cleveland Potato Phos......	†2.14	†2.07	†2.14	†2.10	†2.14	*2.06*	8.18	8.02	8.66	8.18	8.26	*8.*	3.32	3.00	3.12	3.85	3.21	*3.*
Cleveland Superphosphate.	†2.10	†2.17	†2.14	†2.10	†2.17	*2.06*	8.33	8.49	9.02	8.06	8.08	*8.*	1.80	1.81	1.99	1.80	1.92	*1.5*
Crocker's Am. Corn Phos...	†2.28	†2.39	†2.21	†2.07	†2.01	*2.06*	8.12	9.60	8.66	8.02	8.14	*8.*	1.75	1.86	2.01	1.92	2.25	*1.5*
Crocker's Grass and Oats...	......	......	......	......	......	......	11.48	10.67	11.56	11.32	10.55	*11.*	2.52	2.29	2.20	2.43	2.05	*2.*
Crocker's H. G. Special....	......	......	......	......	......	......	......	......	......	......	8.74	*8.*	......	......	......	......	4.57	*4.*
Crocker's N. Y. Special.....	......	......	......	......	1.70	*1.65*	......	......	......	......	11.02	*10.*	......	......	......	......	7.99	*8.*
Crocker's N. Rival Am. Bo.	1.26	1.30	1.37	1.16	1.16	*1.03*	8.47	7.86	8.54	8.04	8.82	*8.*	2.22	2.14	2.44	1.95	2.05	*2.*
Crocker's Pot., Hop & Tob.	†2.28	†2.49	†2.12	†2.10	†2.05	*2.06*	8.08	7.78	8.54	7.87	7.68	*8.*	3.28	3.94	3.12	3.78	3.22	*3.*
Crocker's Potato Special....	†3.65	†3.68	†3.33	†3.30	†3.33	*3.3*	7.02	6.78	6.90	7.32	6.08	*6.*	11.20	10.07	10.45	9.84	10.44	*10.*
Cumberland Potato Fert....	†2.14	†2.39	†2.24	†2.17	†1.95	*2.06*	8.33	8.13	8.72	7.74	8.66	*8.*	3.22	3.21	3.49	3.10	3.78	*3.*
Cumberland Superphos.....	†2.21	†2.07	†2.10	†2.24	†2.14	*2.06*	8.28	8.05	8.36	8.00	7.98	*8.*	1.68	1.94	2.03	1.87	1.82	*1.5*
Darling's Farm Favorite....	†2.28	†2.28	†2.12	†2.21	†2.05	*2.06*	8.17	7.64	8.88	8.12	7.96	*8.*	3.42	3.20	3.38	3.32	3.01	*3.*
Darling's Potato Manure...	†2.60	†2.70	†2.53	†2.88	†2.67	*2.5*	6.59	7.32	6.40	8.02	7.24	*6.*	5.32	6.76	5.52	6.30	5.83	*5.*
Great East. Garden Special	†3.26	†3.54	†3.65	†3.30	†3.65	*3.3*	8.70	8.93	7.79	8.00	8.18	*8.*	7.54	7.18	7.72	7.10	7.26	*7.*

ANALYSES OF LICENSED FERTILIZERS—1904-1908

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
American Agricultural Chemical Co.'s	Great East. General Fert....	1.30	0.95	1.09	1.09	1.44	*0.82*	8.20	7.80	8.06	8.08	7.70	*8.*	4.06	4.04	4.70	4.03	5.09	*4.*
	Great East. Grass and Oats	......	......	......	......	......	......	11.04	11.15	10.73	11.60	10.45	*11.*	2.38	2.21	2.30	2.01	1.99	*2.*
	Great East. No. Corn Spec.	†2.24	†2.24	†2.14	†2.60	†2.21	*2.06*	8.15	8.02	8.42	8.60	8.40	*8.*	1.78	2.01	2.23	1.72	1.89	*1.5*
	Great East. Potato Manure	†2.39	†2.24	†2.14	†2.24	†2.17	*2.06*	8.35	8.05	8.78	8.18	8.20	*8.*	3.24	3.42	3.32	3.44	3.20	*3.*
	Pac. Gu. Co.'s Nobsque Gu.	1.40	1.09	1.40	1.30	1.37	*1.03*	8.45	7.70	8.32	8.15	8.74	*8.*	2.21	3.26	2.32	2.02	2.02	*2.*
	Pac. Gu. Co.'s Potato Spec.	†2.53	†2.42	†2.24	†2.39	†2.07	*2.06*	8.27	8.60	9.00	8.08	8.28	*8.*	3.48	3.34	3.40	3.02	3.22	*3.*
	Pac. Gu. Co.'s Sol. Pac. Gu.	†2.17	†2.24	†2.21	†2.56	†2.14	*2.06*	8.10	7.79	8.24	8.02	8.70	*8.*	1.80	2.05	2.14	1.62	1.98	*1.5*
	Quinnipiac Climax Phos....	1.47	1.40	1.40	1.26	1.37	*1.03*	8.54	7.95	8.26	7.84	8.84	*8.*	2.06	2.68	2.26	1.94	1.99	*2.*
	Quinnipiac Corn Manure...	†2.35	†2.39	†2.28	†2.24	†2.05	*2.06*	8.64	7.90	8.84	8.16	8.18	*8.*	1.82	1.70	2.19	1.80	2.08	*1.5*
	Quinnipiac Market Garden	†3.37	†3.44	†3.58	†4.07	†3.40	*3.3*	8.10	8.68	7.92	7.99	8.03	*8.*	6.93	7.21	8.18	7.84	6.96	7.
	Quinnipiac Potato Phos.....	†2.24	†2.35	†2.21	†2.21	†2.07	*2.06*	8.29	8.60	8.86	8.30	8.50	*8.*	3.08	3.56	3.51	3.12	3.28	*3.*
	Read's Farmers' Friend.....	†2.24	†2.49	†2.17	†2.24	†1.81	*2.06*	8.06	8.26	8.96	8.26	8.30	*8.*	3.00	4.21	3.40	3.30	3.62	*3.*
	Read's H. G. F.'s Friend...	†3.09	†3.51	†3.68	†3.72	†3.12	*3.3*	8.14	6.40	6.94	6.56	6.30	*6.*	10.14	10.52	11.42	11.27	10.47	*10.*
	Read's Leader Bl. and Bone	1.26	1.19	1.26	1.16	1.19	*0.82*	6.89	6.49	8.12	7.02	8.28	7.	1.16	1.58	1.34	1.39	1.32	*1.*
	Read's Prac. Potato Spec'l	1.05	0.98	1.16	1.26	1.51	*0.82*	4.55	6.46	7.68	6.99	7.24	*4.*	8.62	7.86	8.64	8.08	10.03	*8.*
	Read's Standard Superphos.	1.33	0.95	1.19	1.09	1.47	*0.82*	8.29	8.27	8.44	8.08	7.67	*8.*	4.09	4.00	4.06	4.09	5.07	*4.*
	Read's Sure Catch Fert......	......	......	......	......	......	......	10.37	10.94	10.74	10.88	10.06	*10.*	2.20	2.32	2.18	2.22	1.57	*2.*

ANALYSES OF LICENSED FERTILIZERS—1904-1908

Am. Agricultural Chemical Co.'s

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Tucker's Imperial all Crops	1.33	1.26	1.33	1.33	1.07	*1.03*	8.70	8.54	8.32	8.50	9.66	*8.*	2.14	2.26	2.52	2.30	2.22	*2.*
Tucker's Imperial Corn......	1.33	1.05	1.33	1.26	0.88	*1.03*	8.69	7.40	8.28	8.16	9.56	*8.*	2.28	2.20	2.57	2.14	2.17	*2.*
Tucker's Imperial Potato...	1.40	1.33	1.44	1.23	1.12	*1.03*	8.54	8.31	8.34	8.02	9.70	*8.*	2.20	2.16	2.68	2.09	2.31	*2.*
W. & Cl. Am. Corn Phos...	†2.32	†2.21	†2.17	†2.60	†1.96	*2.06*	8.05	8.72	8.58	8.56	8.48	*8.*	1.80	1.85	1.73	2.04	1.79	*1.5*
W. & Cl. Am. High Gr. Sp.	†3.35	†3.72	†3.58	†3.40	†3.44	*3.3*	8.71	8.70	8.11	8.28	8.01	*8.*	7.40	7.75	7.18	7.03	7.26	*7.*
W. & Cl. Am. Potato Man.	†2.32	†2.32	†2.14	†2.32	†2.10	*2.06*	8.15	7.95	9.18	8.08	8.16	*8.*	3.40	3.36	3.40	3.79	3.15	*3.*
W. & Cl. Am. Potato Phos.	†2.91	†2.70	†2.53	†2.95	†2.74	*2.5*	7.51	8.02	6.18	7.40	7.28	*6.*	6.41	6.90	5.40	6.86	5.60	*5.*
W. & Cl. Prolific Crop Pro.	1.23	1.51	1.26	1.12	1.37	*0.82*	7.22	7.46	6.12	8.20	8.14	*7.*	1.20	2.47	1.42	2.00	1.25	*1.*
W. & Cl. Royal Bone Phos.	1.26	†1.16	1.33	1.26	1.33	*1.03*	8.76	7.80	8.90	8.42	8.80	*8.*	2.07	2.25	2.25	2.00	1.95	*2.*
Bowker's Corn Phosphate..	†1.89	†1.79	†2.17	†2.00	†1.61	*1.65*	8.15	8.36	8.42	8.60	8.54	*8.*	2.24	2.15	2.58	2.32	2.15	*2.*
Bowker's Early Potato Man.	†3.44	†3.33	†3.72	†3.51	†3.58	*3.29*	8.25	7.27	7.74	7.56	8.28	*7.*	7.62	7.44	7.70	7.42	6.70	*7.*
Bowker's Hill and Drill....	†2.67	†2.63	†2.77	†2.60	†2.86	*2.47*	8.56	9.63	9.31	9.26	9.44	*9.*	2.10	2.15	2.56	2.17	2.68	*2.*
Bowker's Market Garden...	†2.46	†2.56	†3.02	†2.60	†2.77	*2.47*	6.36	6.10	6.12	6.48	6.66	*6.*	9.78	10.90	10.79	10.04	9.85	*10.*
Bowker's Potash Bone......	†1.05	1.05	1.40	1.12	1.12	*0.82*	6.27	6.08	8.76	8.10	8.76	*6*	2.26	2.41	2.12	2.12	1.93	*2.*
Bowker's Potash or Staple.	†1.12	†1.05	1.23	1.19	†1.30	*0.83*	8.02	7.54	8.58	7.62	8.98	*8.*	3.26	2.93	3.54	3.24	3.58	*3.*
Bowker's Pot. and Veg. F.	†2 49	†2.49	†2.56	†2.81	†2.32	*2.47*	8.55	8.17	9.06	9.44	8.42	*8.*	3.74	4.43	4.40	4.72	4.57	*4.*

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Bowker's Pot. and Veg. P.	1.79	1.82	† 2.17	† 1.89	† 1.65	*1.66*	(a) 7.93	(a) 8.22	(a) 8.31	8.82	8.70	*8.*	2.40	2.11	2.48	2.31	2.19	*2.*
Bowker's Square Brand....	2.00	† 2.10	† 2.14	† 1.96	† 2.09	*1.65*	7.94	5.77	8.56	6.72	8.22	*6.*	2.22	2.48	2.55	2.64	2.33	*2.*
Bowker's Stkbdg. Corn M.	† 3.65	† 3.30	† 3.79	† 3.51	† 3.55	*3.29*	9.80	10.28	9.26	9.02	8.28	*10.*	7.26	7.27	7.58	7.60	7.01	*7.*
Bowker's Stkbdg. Grass...	......	†......	......	† 6.03	† 4.91	*4.93*	......	......	......	6.06	4.44	*4.*	......	......	......	6.51	7.85	*6.*
Bowker's Stkbdg. Pot. M.	† 3.91	3.47	† 3.54	† 3.33	† 3.24	*3.29*	7.25	6.68	5.98	6.60	6.14	*6.*	9.96	10.06	9.94	10.10	10.27	*10.*
Bowker's Super with P't'sh	......	......	......	......	......	......	......	......	......	11.40	9.93	*10.*	......	......	.....	2.52	1.50	*1.*
Bowker's Sure Crop Phos..	† 1.02	† 0.95	1.54	1.09	1.16	*0.82*	(a) 8.90	(a) 8.03	(a) 7.72	8.23	9.06	*8.*	2.08	2.00	2.50	1.95	2.02	*2.*
Bowker's Vt. Grange Ch..	† 2.39	† 2.28	† 2.17	......	† 2.17	*2.06*	8.71	9.16	8.84	......	8.02	*8.*	3.64	3.30	3.02	......	3.05	*3.*
Buff. F. Co. Celery & Pot..	......	......	......	......	† 1.68	*1.64*	......	......	......	......	7.71	*8.*	......	......	......	......	10.45	*10.*
Buff. F. Co. Farm. Choice..	† 0.91	0.84	0.98	0.98	† 1.09	*0.82*	9.81	8.38	8.13	6.28	8.48	*8.*	* 4.02	* 5.98	* 4.40	4.14	5.02	*5.*
Buff. F. Co. Fish Guano....	0.91	0.88	1.05	1.43	† 1.26	*0.82*	(a) 9.13	(a) 9.87	9.14	6.76	9.28	*9.*	* 2.06	* 1.86	* 2.54	3.14	3.25	*2.*
Buff. F. Co. General Crop..	......	......	......	......	......	......	......	10.35	8.90	9.20	10.77	*9.*	......	* 1.68	* 2.35	3.65	5.15	*3.*
Buff. F. Co. Id. Wht. & Co.	1.33	1.44	1.68	1.51	† 1.93	*1.64*	10.17	10.96	8.71	7.60	8.52	*9.*	* 3.99	* 4.31	* 5.00	5.06	4.59	*5.*
Buff. F. Co. Veg. and Pot..	† 1.97	† 2.46	† 2.28	† 1.79	† 2.03	*2.46*	11.23	9.50	8.14	7.20	7.70	*8.*	* (b) 6.92	* (b) 8.32	* (b) 9.02	6.74	5.93	*7.*
Burl. R. Co. Animal Brand	......	2.78	2.74	2.80	2.95	*2.*	......	4.81	4.66	6.44	5.32	*4.*	......	4.91	3.82	4.10	4.50	*4.*
Burl. R. Co. Spec. Potato..	......	......	......	2.91	2.95	*2.47*	......	......	......	6.76	5.06	*5.*	......	......	......	5.42	7.34	*6.*

(a) Available phosphoric acid guaranty, 9 percent. (b) Potash guaranty, 8 percent.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Coe-Mort. Corn and Potato.	1.79	1.66	1.46	......	1.26	*1.23*	10.20	8.95	8.70	......	8.06	*8.5*	*2.82	*3.03	*2.57	......	2.43	*2.5*
Coe-Mort. Gold Brand.......	†2.53	†2.17	†2.56	†2.00	†2.42	*2.4*	9.74	8.99	8.76	5.52	8.05	*8.*	*5.34	*4.64	*6.06	9.40	5.67	*6.*
Coe-Mort. H. G. A. B. Super	†2.39	†2.46	†2.14	......	2.03	*1.85*	10.28	9.67	9.00	.....	9.74	*9.*	*2.72	*2.90	*2.40	......	2.84	*2.25*
Coe-Mort. New Eng. Corn...	1.33	1.33	1.05	0.91	†1.40	*0.8*	9.60	9.67	8.68	5.73	9.36	*7.5*	*3.04	*3.18	*3.01	*3.23	3.05	*3.*
Coe-Mort. New Eng. Potato	1.65	1.44	1.02	0.95	0.98	*0.8*	9.88	9.07	8.51	5.70	8.28	*7.5*	*3.08	*3.52	*3.31	*3.49	2.62	*3.*
Coe's Prize Br. Grass & Gr.	......	......	......	......	......	.....	9.90	9.53	11.50	......	11.18	*10.*	*2.26	2.18	*2.03	......	1.64	*2.*
Essex A 1 Superphos.........	......	......	......	.....	1.14	*1.2*	......	......	......	......	8.42	*7.*	......	......	......	......	2.13	*2.*
Essex Comp. Corn, etc......	......	......	.....	......	†3.13	*3.28*	......	......	......	......	6.10	*6.*	.....	......	......	......	10.44	*10.*
Essex Comp. Potatoes, etc..	......	......	......	......	†3.44	*3.25*	......	......	......	......	5.58	*7.*	......	......	......	......	10.80	*10.*
Essex Grass and Grain......	......	......	......	......	1.02	*0.82*	......	......	......	......	9.08	*8.*	......	.....	......	......	4.46	*4.*
Essex Mar. Garden & Pot..	......	......	......	......	1.98	*2.*	......	......	......	......	7.93	*8.*	......	......	......	......	5.55	*5.*
Essex XXX Fish & Pot....	......	......	......	......	2.10	*2.*	......	......	......	......	9.14	*8.*	......	......	......	......	3.04	*3.*
Lister's A. B. & Pot. No. 2	......	......	......	......	......	......	9.36	11.01	10.84	9.76	10.14	*10.*	2.60	2.25	2.21	2.01	2.17	*2.*
Lister's G. Brand.............	0.98	0.95	1.19	0.88	0.98	*0.82*	7.60	9.56	8.70	8.64	8.16	*8.*	4.40	3.73	4.02	4.03	3.94	*4.*
Lister's Grass and Oats......	......	......	1.05	......	0.95	*0.82*	......	......	8.18	......	8.05	*8.*	......	......	4.16	......	3.70	*4.*
Lister's Oneida Special......	1.42	0.95	0.91	0.98	0.98	*0.83*	8.13	7.11	7.04	7.70	7.34	*7.*	1.88	1.37	1.24	1.17	1.33	*1.*

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Lister's Potato Manure......	†3.18	†3.61	†3.51	†3.68	†3.61	*3.3*	9.28	8.74	8.48	9.28	8.75	*8.*	6.66	7.94	7.07	7.00	7.26	*7.*
Lister's Special Corn Fert..	†2.07	2.00	†1.75	1.82	1.79	*1.65*	8.51	8.78	8.62	8.42	8.55	*8.*	3.54	3.34	3.46	3.30	3.49	*3.*
Lister's Special Pot. Fert...	†2.24	2.00	†1.75	1.79	1.89	*1.65*	8.80	8.36	8.66	8.12	9.07	*8.*	3.24	3.23	3.13	3.18	3.35	*3.*
Lister's Special 10% Potato	......	1.86	†2.00	1.72	1.79	*1.65*	......	8.79	9.34	8.46	9.80	*8.*	......	11.62	10.01	7.97	10.41	*10.*
Lister's Success Fertilizer..	†1.82	1.40	1.40	1.40	1.30	*1.24*	9.28	9.38	10.02	9.08	9.42	*9.*	2.44	2.19	2.20	2.50	2.24	*2.*
Lowell (Swift's) Animal...	2.63	2.60	2.53	2.42	2.46	*2.47*	(c) 9.73	(c) 9.73	10.06	8.28	8.32	*8.*	4.02	4.06	4.18	4.35	4.15	*4.*
Lowell (Swift's) Bone Ft.	1.89	1.68	1.93	2.00	1.72	*1.64*	8.03	9.16	9.30	7.77	8.44	*8.*	3.12	3.43	3.24	3.24	3.26	*3.*
Lowell (Swift's) Cereal.. ...	......	1.09	0.95	1.16	1.02	*0.83*	......	7.72	6.52	7.84	7.32	*7.*	......	1.40	1.16	1.64	1.57	*1.*
Lowell (Swift's) Empress..	1.01	1.26	1.44	1.30	1.37	*1.23*	8.20	7.26	7.62	7.54	7.34	*7.*	2.60	2.50	2.09	2.01	2.23	*2.*
Lowell (Swift's) Pot. Man.	1.93	2.03	1.75	1.79	1.74	*1.64*	7.36	8.75	8.12	7.38	7.78	*7.*	*4.14	*3.94	4.34	3.02	4.08	*4.*
Lowell (Swift's) Pot. Phos.	†2.77	2.84	2.49	2.24	2.70	*2.46*	8.15	9.16	8.20	8.79	7.66	*8.*	*6.30	*6.00	6.28	*5.30	5.67	*6.*
Lowell (Swift's) Sterling...	......	0.98	0.98	0.84	1.02	*0.82*	......	8.23	8.66	7.84	8.21	*8.*	......	3.65	3.62	4.28	4.06	*4.*
Lowell (Swift's) Superior..	......	......	†3.96	†3.79	†3.86	*3.7*	......	.....	8.76	7.40	7.60	*7.*	......	......	9.75	9.75	9.78	*10.*
N. E. F. Co., Corn & Grain	1.54	1.53	1.23	1.40	1.23	*1.23*	8.27	7.84	7.58	7.52	7.06	*7.*	2.56	2.45	2.20	1.88	2.06	*2.*
N. E. F. Co., Corn Phos......	1.75	1.86	1.89	1.82	1.84	*1.64*	8.03	7.98	9.62	7.76	8.00	*8.*	3.04	3.00	3.25	3.00	3.22	*3.*
N.E.F. Co., H.G. 10% Pot.	......	......	......	†3.79	3.81	*3.5*	......	......	......	7.00	7.04	*7.*	......	......	......	10.18	9.95	*10.*

(c) Available phosphoric acid guaranty, 9 percent.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
N. E. F. Co., Peerless........	......	....	......	......	0.98	*0.82*	......	......	......	......	6.89	*7.*	......	......	......	......	1.23	*1.*
N. E. F. Co., Potato Fert..	2.03	1.86	1.86	1.75	1.89	*1.64*	7.49	7.85	8.14	7.28	7.12	*7.*	*4.06	*4.13	*4.13	*3.47	4.06	*4.*
P.&P. Co.'s Aroostook Spl.	......	......	......	†3.86	†3.68	*3.7*	......	......	......	7.20	7.48	*7.*	......	......	......	10.21	9.74	*10.*
P. & P. Co.'s Grain Grower	......	......	1.12	1.33	1.47	*1.23*	......	......	8.02	6.66	7.32	*7.*	......	......	2.02	1.92	2.36	*2.*
P. & P. Co.'s Plym'h Rock	......	2.63	2.49	2.62	2.49	*2.47*	......	8.11	8.34	7.75	8.20	*8.*	......	4.08	4.11	3.86	4.32	*4.*
P. & P. Co.'s Potato Fert...	......	......	1.72	1.86	1.89	*1.65*	......	......	6.96	6.30	6.04	*6.*	......	......	6.87	7.44	4.16	*6.*
P. & P. Co.'s Pot. Grower..	......	......	......	......	†2.49	*2.46*	......	......	......	......	6.26	*6.*	......	......	......	......	9.69	*10.*
P. & P. Co.'s Spec. Potato..	......	†3.33	†3.30	†3.30	†3.18	*3.29*	......	8.36	8.60	8.14	9.94	*8.*	......	7.34	7.28	7.56	7.15	*7.*
P. & P. Co.'s Star Brand...	......	1.64	1.75	1.65	2 24	*1.65*	.....	6.91	7.02	7.28	7.16	*7.*	......	(g) 2.50	(g) 2.78	3.98	4.15	*4.*
R. & H. Co.'s Compl. Phos	......	†1.12	†1.47	†1.16	†1.12	*1.*	......	9.61	8.86	8.04	8.42	*8.*	......	4.17	4.72	4.66	4.03	*3.5*
R. & H. Co.'s Grass & Gr...	......	†2.46	2.81	3.33	3.05	*2.2*	......	8.39	8.06	6.03	7.12	*6.6*	......	12.00	12.66	14.43	10.83	*12.*
R. & H. Co.'s Oats & Top Dr.	......	†8.65	†8.54	†8.21	†8.70	*8.5*	......	4.69	5.48	4.25	4.83	*3.9*	......	10.00	8.02	9.80	10.29	*8.*
R. & H. Co.'s Potato Phos.	......	†2.07	†2.12	†2.35	†2.24	*2.*	......	9.79	8.40	9.82	8.82	*9.*	......	5.41	5.54	6.29	6.10	*5.*
R. & H. Co.'s Sol.Co.G'l Cp.	......	†3.12	†2.70	†2.35	†2.35	*2.5*	......	6.79	6.14	7.84	6.40	*6.*	......	8.40	9.25	8.85	9.14	*8.*
R. & H. Co.'s Sol. Potato...	......	†5.57	†4.35	†4.53	†4.95	*5*	......	7.97	7.36	7.95	8.48	*7.*	......	*5.86	*7.38	*6.93	*6.50	*5.*
R. H. & Co.'s Sol. Tobacco	....	......	†5.75	†5 30	†4.55	*5.*	.....	......	8.88	9.82	8.04	*7.*	......	......	*9.61	*10.92	*14.46	*10.*

(g) Potash guaranty, 2.5 percent.

VII. A QUARTER CENTURY OF FERTILIZER INSPECTION IN VERMONT

A regular and annual control of the sale of commercial fertilizers has been in vogue in Vermont for 25 years. It seems fitting that the results be collated, compared and the salient features observed, both as matter of historical record and in order to note the trend of the times.

The control has been carried out under three enactments, passed in 1882, 1888 and 1902. It was under the direction of the secretary of the State Board of Agriculture and of the ex-officio State chemist from 1883 to 1887, and of the station director from 1888 to date. The present law may be found in chapter 213, Public Statutes, sections 4973-4982, 4989-4993. The intent of each law was identical, i. e. to provide that manufacturers "state what they sell and sell what they state." The last enactment is better suited to present day conditions than were its predecessors, omitting unnecessary requirements and restrictions, modernizing and clarifying the language, and providing certain additional safeguards. Among the discarded provisions of earlier enactments are: the filing of $5,000 bonds, the forfeiture of $1,000 for each violation of the law, heavy fines for the sales of unguarantied goods; statement on each package of year of manufacture, of "constituent parts," of number and of date of license; the filing of certified statements as to guaranties, of sworn samples and of lists of local dealers; all of them indications of the antagonistic attitude of the farmers of the eighties towards the manufacturers of that day. Among the added provisions may be mentioned: definitions; proper guaranty statement; the use of standard methods of analysis; the prohibition of the use of inferior ammoniates; the financing of the control from fees paid by manufacturers; simplification of sampling operations; enlargement of opportunity for publication of matter in relation to the character, composition, value and use of fertilizers; prosecution in cases of failure on the part of manufacturers substantially to make good their guaranty statements.

The first fertilizer law was passed in Massachusetts in the middle seventies. That there was need of a similar act in Vermont was shown ten years before its enactment. Apparently the first public presentation of the commercial fertilizer situation was made by Dr. Peter Collier, then Professor of Chemistry of the University, later chemist of the United States Department of Agriculture, and yet later, director of the New York Station. In the first (1872) report of the State Board of Agriculture, of which body he was then secretary, he discussed at length: commercial fertilizers, plant food, soil exhaustion, the money values of fertilizers, superphosphates, reverted phosphoric acid, home mixing, frauds and their prevention, etc. The analyses of 22 brands, including so far as known all then sold in Vermont, were printed with a statement as to their valuations. But two brand names appear which are now familiar, viz.: Bradley's XL Superphosphate of Lime and Cumberland Superphosphate, although the name of Coe also appears.

It is interesting to note some of the differences between 1872 and 1908.

1. But three of the 22 brands carried any potash whatsoever; and two of these three brands less than one percent.

2. Trade values were "out of sight," phosphoric acid rating at thrice the modern figures, nitrogen at 30 cents—twice the price at which it has been sold in recent years—and potash at 7 cents instead of 4¼ cents.

3. Either extreme irregularity of composition was evidenced by the analyses of different samples of the same make, or else inadequacy of sampling. Our present day knowledge of the difficulties of adequate sampling makes the latter hypothesis seem reasonable.

4. One brand carried in all but 14 pounds of nitrogen and 33 pounds of insoluble phosphoric acid per ton, and would be valued to-day at $3.65 a ton.

5. Two brands carried no plant food whatever. One of these was said to be "the pulverized ore from the Grafton (Vt.)

gold mine" and claimed not only to be an incomparable fertilizer but also to be of service for cleaning knives, glass and paint, for insect destruction, and as a substitute for Bristol brick. The other, discovered by a "German chemist," was recommended not only as a fertilizer but as a deodorizer and disinfectant, as a soft soap maker and a cure for poison ivy infection. The first was an impure dolomitic limestone, the second simply sand. The usual testimonials were offered for each.

At least twice since the enactment of the fertilizer law quite as barefaced frauds have been perpetrated; but owing to the more general diffusion among the people of information touching fertilizers their vogue has not been great. Hall's Coral Fertilizer, "manufactured" in 1888 by the Vermont Chemical Fertilizer Co. of Vergennes, proved to be ground limestone rock, worth at the outside 35 cents a ton for its phosphoric acid and potash content. Yet later (1897) the Harvester Fertilizer, manufactured by the Harvester Fertilizer Co. of Mechanicsville, N. Y., was found to be three-quarters by weight ground limestone, and carried potash valued at 13 cents a ton. It sold for nine dollars. Ground limestone has value as a soil amendment; but it ought not to be sold as a "mineral," "coral," or "harvester" fertilizer.

During these 25 years a multitude of different brands have been sold and over 2100 samples analyzed. Companies have entered the State and left again, remaining, some for a year, some for years, and some forever. In 1883 the following companies sold goods in Vermont: Bradley Fertilizer Co., Pacific Guano Co., J. A. Tucker & Co., all of Boston; the Quinnipiac Fertilizer Co. of New London, Conn., the Cumberland Bone Co. of Portland, Me., and L. L. Crocker & Co. of Buffalo, N. Y., all now constituent branches of the American Agricultural Chemical Co.; the Michigan Carbon Works of Detroit; the Dole Common Sense Fertilizer Co. of Boston; the Slack Fertilizer Co. of Springfield, Vt.; and the Bowker Fertilizer Co. of Boston. The latter alone sells to-day under its original name.

The companies now selling entered the State as follows American Agricultural Chemical Co., 1901 (as several constituent branches, 1872 or before to 1898); Bowker Fertilizer Co., 1883 (or before); Buffalo Fertilizer Co., 1904; Burlington Rendering Co., 1905; Coe-Mortimer Co., 1906 (as E. Frank Coe Co. 1872 or before); Lister's Agricultural Chemical Works, 1885; Lowell Fertilizer Co., 1896; New England Fertilizer Co., 1901; Parmenter & Polsey Fertilizer Co., 1905 (also in 1897); Rogers & Hubbard Co., 1905; Essex Fertilizer Co., 1908 (as Russia Cement Co. 1897).

The following brands now sold in Vermont were first met with in inspections from 1883 to 1893, as indicated:

1883. Bradley's XL Superphosphate, Soluble Pacific Guano, Cumberland Superphosphate, Bowker's Hill and Drill Phosphate, Bowker's Stockbridge Manure (brand not stated).

1885. Quinnipiac Potato Phosphate, Clark's Cove Bay State, Crocker's Potato, Hop and Tobacco, Williams & Clark's Americus (brand not stated), Lister's Potato Fertilizer, Coe's High Grade Superphosphate.

1887. Bradley's Potato Manure, Williams & Clark's Americus Potato Manure, Bowker's Potato Phosphate.

1888. Cleveland Superphosphate and Potato Phosphate, Lister's Success Phosphate, Bowker's Sure Crop Phosphate, Clark's Cove King Philip Alkaline Guano, Bradley's Complete Manure.

1889. Bowker's Stockbridge Potato Manure, Bowker's Corn Manure, Bowker's Stockbridge Grass and Top Dressing, Cleveland Potato Manure.

1890. Bradley's Eclipse Phosphate, Williams & Clark's Ammoniated Bone Superphosphate, Crocker's Ammoniated Corn Phosphate.

1891. Bradley's Corn Phosphate, Lister's Potato Manure.

1892. Crocker's New Rival Ammoniated Bone Superphosphate, Bradley's Potato Fertilizer, Bowker's Potato Phosphate, Lister's Corn Manure.

1893. Pacific Guano Co.'s Special Potato, Quinnipiac Corn Manure, Quinnipiac Climax Phosphate, Crocker's Special Potato, Williams & Clark's Americus Corn Phosphate.

Three estimates of the volume of the trade have been made. In 1889 it was thought to be about 4,200 tons; in 1899, 16,000 tons; to-day there is reason to believe it approximates 18,000 tons annually.

Turning now specifically to the results attained and to the lessons to be drawn from the control of the past 25 years, attention is directed to the several graphic charts presented on pages 120-138, showing thus the data usually presented in tabular form. It may be remarked at once that the less thorough inspections of the earlier years—1883-1893—were due to lack of funds and that for several years there were doubtless many brands sold which were not sampled. Hence the contour lines of the charts have less validity before 1894 than after that date.[1]

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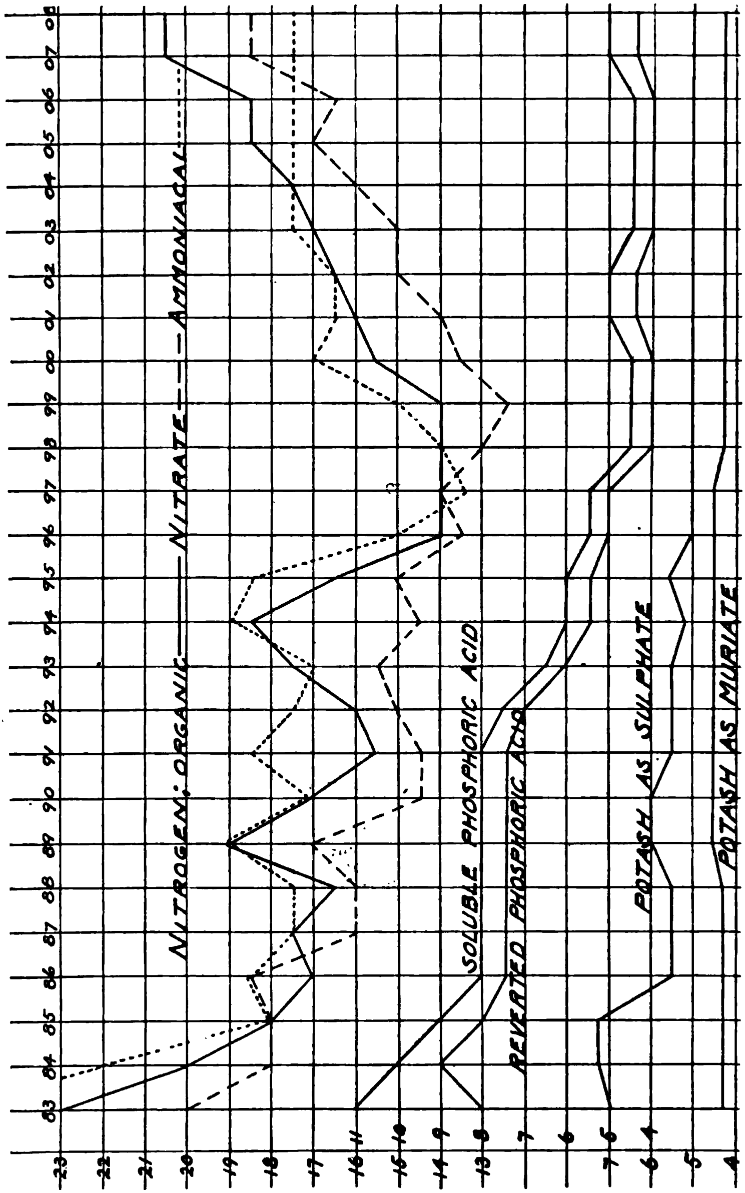
[1] The data upon which these charts are based are drawn from the 1883, 1885 and 1886 State Board of Agriculture reports; 1887 to date, from Station bulletins.

No data appear for 1884. Analyses were made—so the writer is informed by the then analyst—and written report made to the secretary of the State Board for publication; but that official (the late Dr. H. A. Cutting) did not publish them in the board report, so far as can be determined, elsewhere. Diligent search through newspaper files of the mid-eighties (Burlington Daily and Weekly Free Press and Montpelier Watchman), which were peculiarly apt in those days to make much of items of agriculture interest, failed to disclose the data. That there might be no break in the graphically expressed data a careful study of the brands as found on sale in preceding and succeeding years was made, 20 representative ones chosen (the same number as were analyzed the preceding year) and the Connecticut Station analyses thereof used. Doubtless this procedure introduced more or less error in Charts II to VII; but the likelihood that its extent is serious is not great. It should be remembered, morover, that all the data prior to 1895 are based on a somewhat inadequate inspection.


NITROGEN: ORGANIC ——— NITRATE - - - - AMMONIACAL ....
SOLUBLE PHOSPHORIC ACID
REVERTED PHOSPHORIC ACID
POTASH AS SULPHATE
POTASH AS MURIATE
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7 6
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4

CHART I

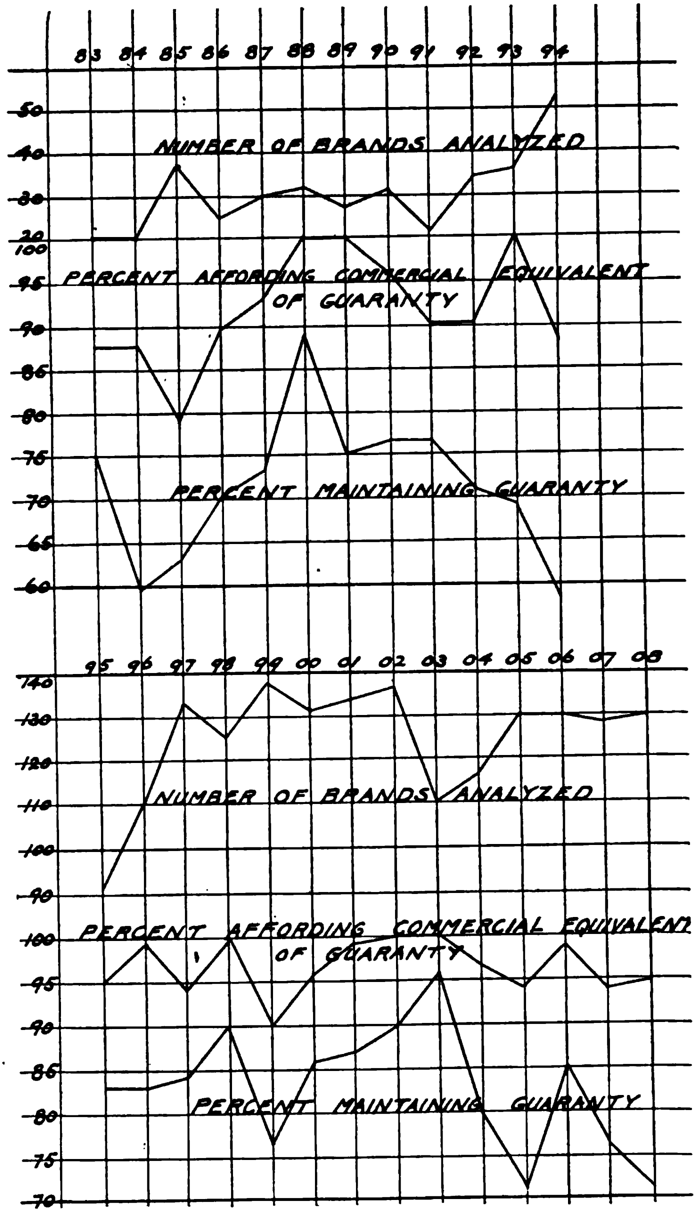
Trade values of nitrogen, phosphoric acid and potash (see pages 67-69 for exposition of meaning of term "trade values").

Nitrogen.—The several forms of nitrogen have maintained a fair parallelism. Nitrate nitrogen has always been its cheapest source, save in 1886 and during the past two years; and sulphate of ammonia its most costly form until 1905, save in 1893 and 1897. To-day sulphate is quoted at lower prices than are either of the other two forms of nitrogen. Organic nitrogen was the cheapest form of the element but once (1886), and the dearest but once, until lately (1893); but since 1904 it has ruled higher in price than have the other forms. As a whole the lines are a great curve, a sharp fall from 1883 to 1888, (from 23 to 16½ cents); and a steady and uninterrupted rise from 1900 to date, with prices on a level with those of 1884-5 (from 14 to 20½ cents).

Phosphoric acid rapidly dropped in price in the mid-eighties (11 to 8 cents for soluble); for six years (1886-1891) maintained its price; and steadily dropped from 1891 to 1898 (from 8 to 4½ cents), since which time it has remained nearly constant at either 4½ or 5 cents for soluble. Reverted from 1886 to date has paralleled soluble at a half cent under, while insoluble has rated immovably at 2 cents.

Potash as muriate has varied but a quarter of a cent, being rated at a uniform price, 4¼ cents, from 1883 to 1888 and from 1898 to date; and, oddly enough, at a higher price, 4½ cents, during the period of depression of the price of ammoniates (1889-1897). The sulphate dropped greatly in 1886 (from 7½ to 5½ cents), but has maintained a nearly stable price since that time and an absolutely stable one (5 cents) for the past 13 years.

Nitrogenous plant food costs from 40 to 50 percent more to-day than it did ten years ago; phosphoric acid and potash do not. The careful buyer will consider seriously other and cheaper ways of getting a part of his needed nitrogen than by its purchase in commercial fertilizer.


83 84 85 86 87 88 89 90 91 92 93 94
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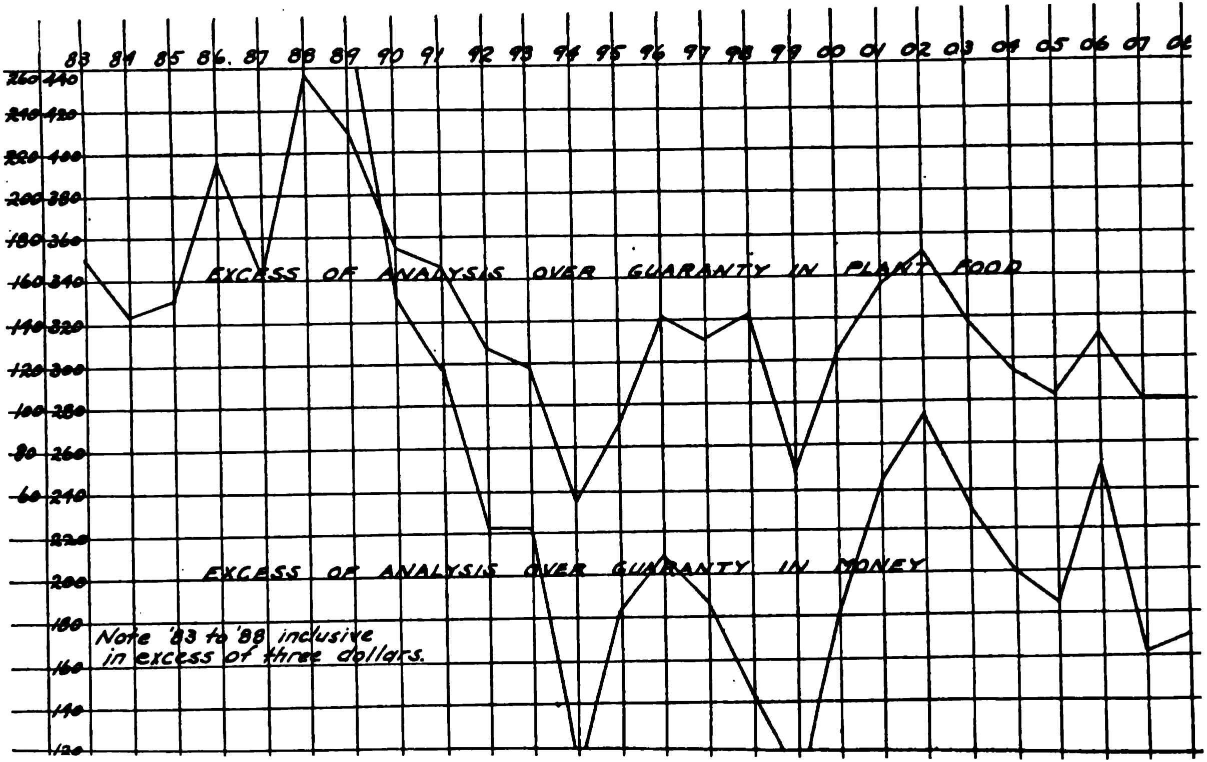
100
95
90
85
80
75
70
65
60
NUMBER OF BRANDS ANALYZED
PERCENT AFFORDING COMMERCIAL EQUIVALENT OF GUARANTY
PERCENT MAINTAINING GUARANTY
95 96 97 98 99 00 01 02 03 04 05 06 07 08
140
130
120
110
100
90
100
95
90
85
80
75
70
NUMBER OF BRANDS ANALYZED
PERCENT AFFORDING COMMERCIAL EQUIVALENT OF GUARANTY
PERCENT MAINTAINING GUARANTY

CHART II

The number of brands analyzed, the proportion meeting guaranty and affording a commercial equivalent thereof. The small numbers of brands sampled from 1883 to 1894 were due to the fact that the then existing laws either made little or no provision for the payment of the expenses incurred, and likewise to the comparatively small extent of the trade during the earlier years. When in 1894 the law was amended so as to overcome this valid objection a more adequate inspection was made. The sag in 1903 and 1904 followed a change in the law, to which it took some time for manufacturers to adjust themselves.

Guaranty maintenance to-day is as good as it was twenty years ago, better than it was during the early nineties, but during four of the past five years it has been poorer than at any time, save in 1899, since 1894. The proportion of brands failing to furnish the commercial equivalent of their guaranties was low in 1891, 1892, 1894 and 1899. The particularly low figures of 1894 were obtained in the first inspection wherein more than 36 samples were taken and wherein any serious attempt was made to cover the State and to get a full representation of the brands offered for sale. It may have been simply a coincidence that so many goods were faulty and had been getting more so under the conditions of inadequate inspection, and that immediate and permanent improvement in this respect followed the inception of more thorough work; and it may not.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240 420
220 400
200 380
180 360
160 340
140 320
120 300
100 280
80 260
60 240
220
200
180
160
140
120
EXCESS OF ANALYSIS OVER GUARANTY IN PLANT FOOD
EXCESS OF ANALYSIS OVER GUARANTY IN MONEY
Note '83 to '88 inclusive
in excess of three dollars.

CHART III

Excess of plant food and of money value found in the average goods as compared with guaranties. Fertilizer manufacturers are not in business for altruistic motives, but to make money. They are required by law to guarantee the plant food contents of their several brands and to maintain them in fact. They naturally deliver no more than they deem necessary and are apt to cling quite closely to their guaranties, more particularly of late years. In the eighties, when retail prices ruled higher, there was less incentive to shave guaranties closely than when they were lowered. The chart is an irregular one. From 1888 to 1894 the tendency was rapidly to lessen the divergency between promise and performance; to widen it again for a year or two and then once more to hug the guaranty in 1899; yet again to widen it, culminating in 1902, and then narrowing it again. Manufacturers are apt to be relatively prodigal in phosphoric acid, but often run risks on nitrogen and potash. There is, of course, no reason for cavil on the buyer's part at the manufacturer clinging to his lower guaranty, since that is all he is bound to give.

The upper line in the chart shows the added excesses in total nitrogen, available phosphoric acid and potash percentages; the lower line, the assumed money value of these excesses at the trade value prices of the several years.

Error. Note at lower left hand corner of chart: "three dollars" should read five dollars.

260—60=2.60—0.60%; 440—120=$4.40—$1.20.

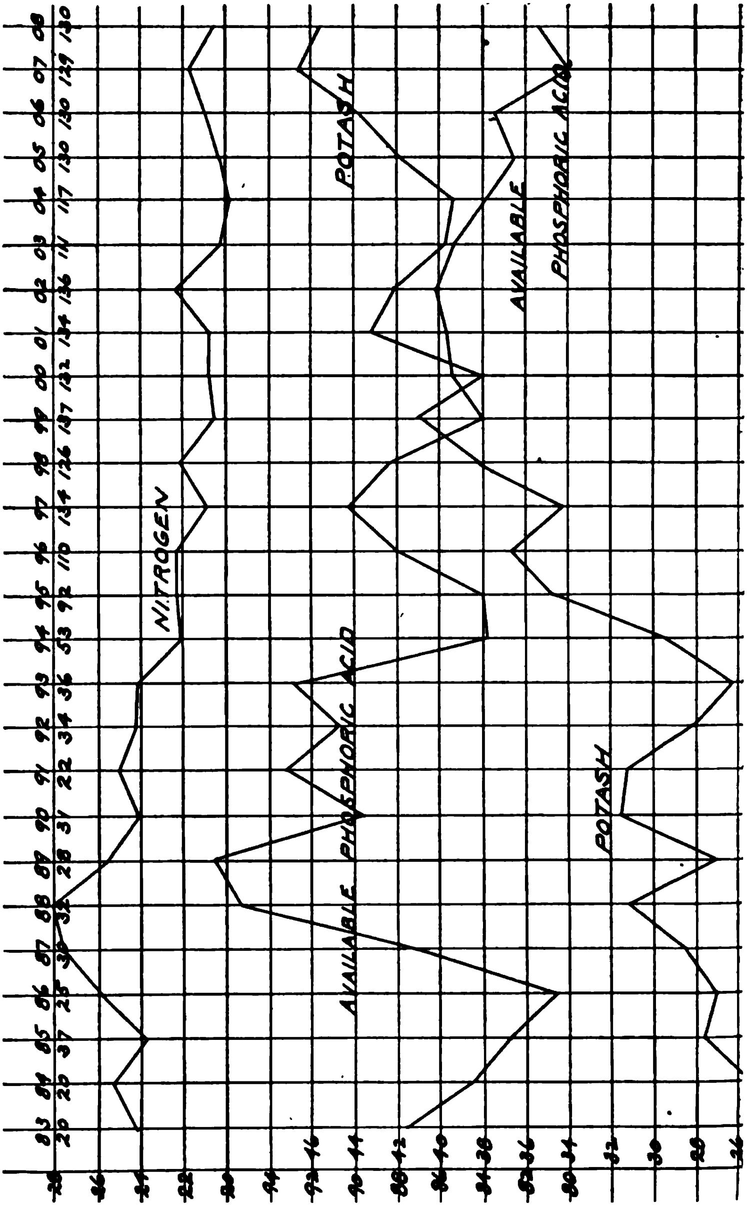

83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
20 25 37 25 30 32 28 31 22 34 36 53 92 110 134 126 127 132 134 136 111 117 130 130 130 129 130
NITROGEN
AVAILABLE PHOSPHORIC ACID
POTASH
AVAILABLE PHOSPHORIC ACID
POTASH
28 26 24 22 20 94 92 90 88 86 84 82 80
46 44 42 40 38 36 34 32 30 28 26

CHART IV

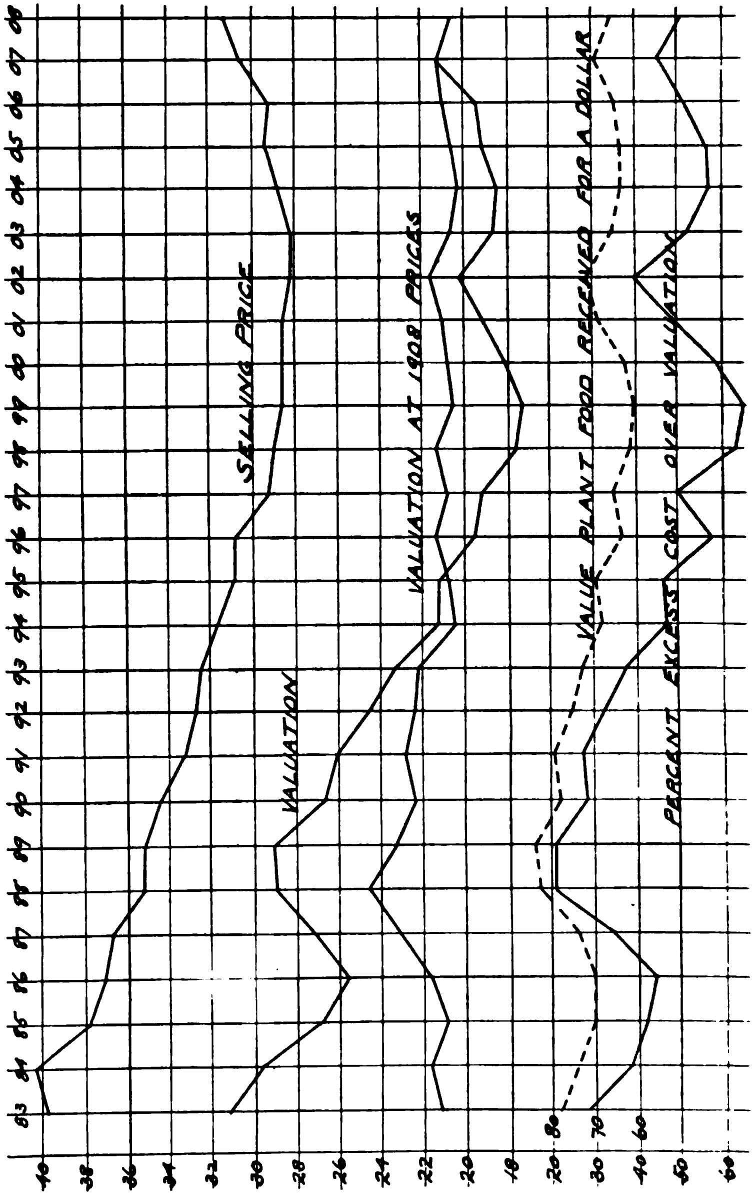
The average analyses of the goods sold in successive years. The suggestive point here is the striking change which has occurred in the character of the average goods. Note:

1. The lessened use of nitrogen and of available phosphoric acid.
2. The great increase in the use of potash.
3. The long, low, downward trend of the nitrogen line; the steady—interrupted to be sure—and somewhat sharp rise of the potash percentages from the 2.20 percent of 1883 to 4.65 percent of 1907; the very irregular yet plainly downward tendency of the phosphoric acid contents from the high point of 1888 and 1889—9.60 percent—to the 1907 low point—8.00 percent. The trends are similar, though less marked, for phosphoric acid and potash during the past 15 years of adequate inspection, as noted in the last year's bulletin:

8.75%	8.47%	8.18%	available phosphoric acid	in 3 successive 5-year periods
3.60%	4.07%	4.51%	potash	

The change is in the right direction.

NOTE.—*Figures at top of chart indicate number of brands analyzed; at left of chart, percentages. 28—20=2.8—2.0% nitrogen; 94—80=9.4—8.0% available phosphoric acid; 46—26=4.6—2.6% potash.*


SELLING PRICE
VALUATION
VALUATION AT 1908 PRICES
VALUE PLANT FOOD RECEIVED FOR A DOLLAR
PERCENT EXCESS COST OVER VALUATION
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
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34
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26
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22
20
18
80
70
60
20
30
40
50
60

CHART V

Selling prices, valuations, excess of cost over valuation, value received for a dollar spent. The selling prices have dropped gradually with the sharp declines from 1885 to 1891 and 1893 to 1897. During the past six years they have been on the up grade. Valuations have naturally followed suit, since the larger part of the cost price of fertilizer is determined by its plant food contents. Hence there is some degree of parallelism between the two lines, the principal divergencies being found in 1901 and 1902. The increase in 1886 to 1888 was caused by the high nitrogen contents of the goods of that time (see Chart IV). The figures naturally vary, as do the trade values (see nitrogen line in Chart I).

For comparative purposes a line is exhibited showing the average goods of each year figured at 1908 trade values. On this basis the average goods of 1887 and 1893 valued more than those made later, owing to their high nitrogen content; but since 1894 these money values have been but slightly varient. The total plant food contents of the average goods are greater to-day than hitherto, owing to the increase in the average potash content.

The percentage increase of cost over valuation is almost a replica of the valuation line, being least in 1888 and 1889 and most ten years later. The low margin of the late eighties, when farmers were buying fertilizers cheaper than ever before or since for the value contained therein, was followed by the failure of several companies selling in New England. It was too narrow a margin for a solvent fertilizer trade. The line showing the value in plant food received for a dollar paid out must naturally bend, as does the excess line just considered, although to a less degree. In the early days of liberal excesses of plant food (see charts III and IV), of high trade values (see chart I), the plant food receipts for a dollar spent were always worth 70 cents or more (1885-1893); but following the panic of that date and to date—save in 1902—they have not again reached that figure, though now nearing it.

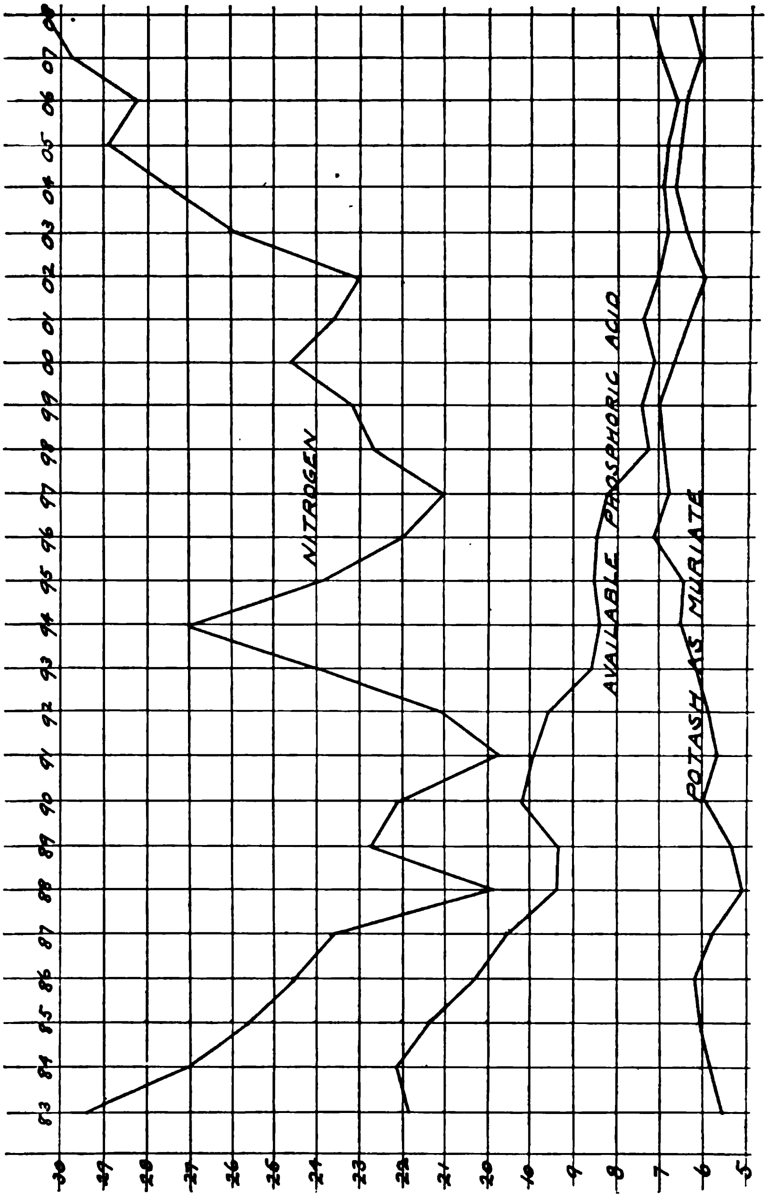
NITROGEN
AVAILABLE PHOSPHORIC ACID
POTASH AS MURIATE
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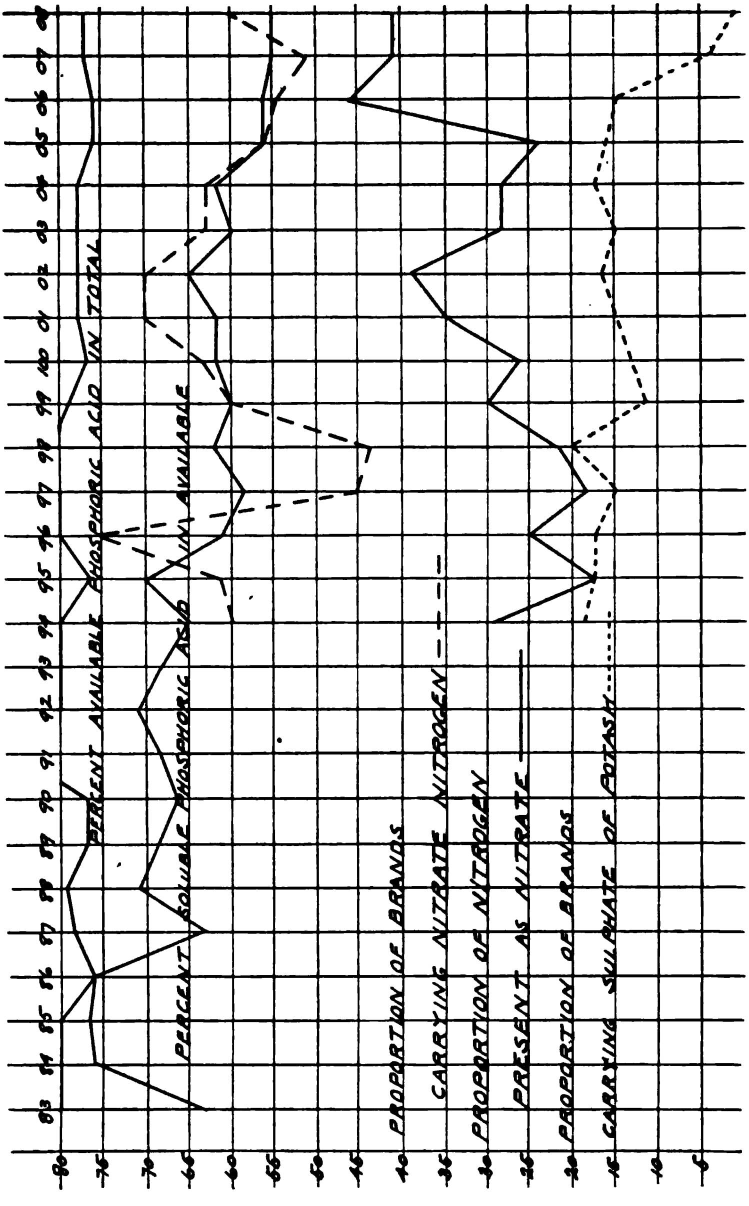
CHART VI.

Cost of plant food in Vermont. Plant food as lain down at Vermont points in retail lots costs more than it does at the seaboard. The local cost of phosphoric acid in mixed goods has gradually fallen, sharply at first, slowly during the past ten years; that of potash as muriate shows a long and graceful low curve, starting at 5½ cents, rising to 7 cents in 1896 and dropping to 6 to-day. Nitrogen is irregular, averaging in round figures 26 cents for five years, 22 cents for the next five years, 25 cents for three, 23 cents for seven, and over 28 cents for the last six years, a pronounced upward trend. Save for its high point in 1893-1895 the nitrogen line approximates a great concave curve. The minerals cost less than they used to; the animal crude stock, more.

NOTE.—*Error. The figures indicating cost of available phosphoric acid per pound (left margin lower part) should have been continued from 10 to 13 to cover the line from 1883 to 1887.*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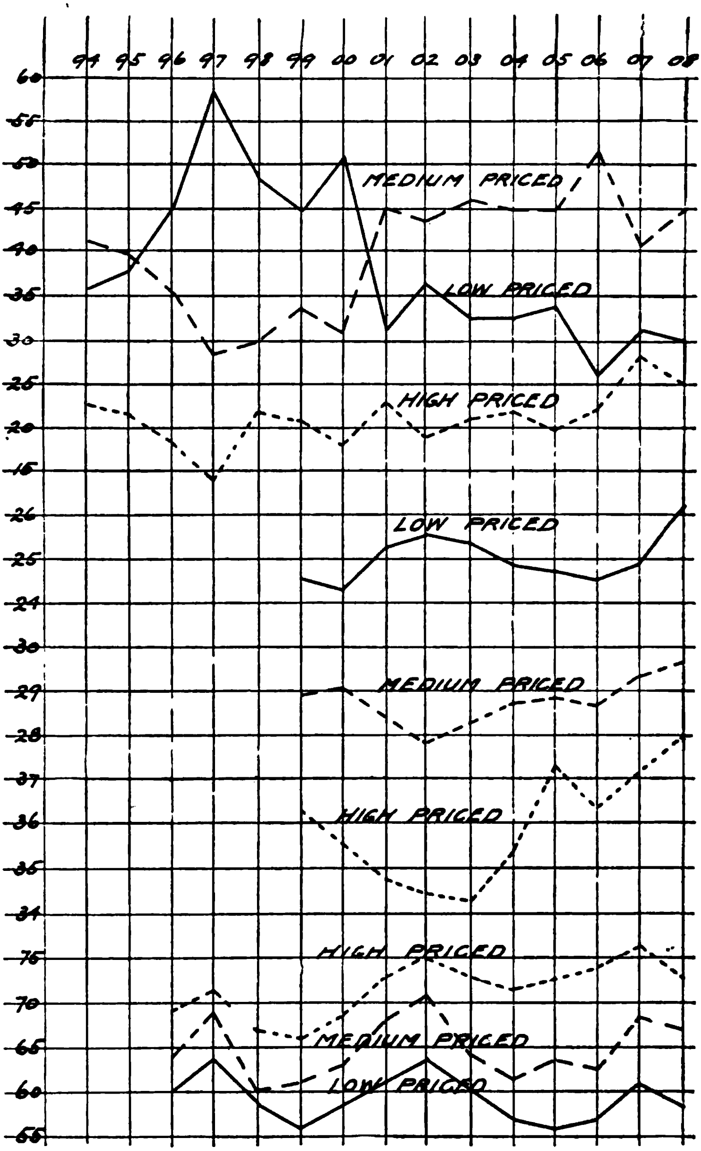
PERCENT AVAILABLE PHOSPHORIC ACID IN TOTAL
PERCENT SOLUBLE PHOSPHORIC ACID IN AVAILABLE
PROPORTION OF BRANDS
CARRYING NITRATE NITROGEN — — —
PROPORTION OF NITROGEN
PRESENT AS NITRATE ———
PROPORTION OF BRANDS
CARRYING SULPHATE OF POTASH ....

CHART VII

Proportion of soluble nitrogen, availability of phosphoric acid, usage of sulphate of potash. The soluble nitrogen and the sulphate of potash contents of each brand have been determined since 1894. Cheap nitrate led to its increased use in 1896, 1901 and 1902, when it was used in 75, 70 and 70 percents of the brands. It has rapidly increased in cost of late years and its use has been abandoned in several brands. But in such as still contain it, it constitutes an increasing proportion. From 1895 to 1898 barely 20 percent of the nitrogen used in goods containing nitrate was in this form; during the next seven years it averaged 30 percent; while during the past three years, despite its higher cost, it has exceeded 40 percent. In other words, the number of brands carrying nitrate are less, but the nitrate content of those carrying it is augmented. Sulphate of ammonia cuts a comparatively small figure in the goods sold in Vermont, although found more commonly in 1908 than for some years.

The proportion of the total phosphoric acid percent in available form has not materially changed with the advancing years. The highest figure is 83, the lowest 76 percent. The tendency is towards less complete acidification and slightly lower availability during the past ten years as compared with the preceding fifteen years. This tendency is decidedly manifest in the proportion of the available acid found as soluble phosphoric acid. There exists to-day much less soluble and much more reverted acid in a given total than was formerly the case. The line trends downwards, and prior to 1895 had sunk below 65 on the scale of 100 but once; since that time it has never been above 65. For 13 years not more than 6 out of 10 pounds of available phosphoric acid have been soluble in water, but for the 12 years preceding it 7 pounds in 10 of the available phosphoric acid was soluble in water. It would seem that buyers are getting less and on the whole somewhat poorer phosphoric acid than formerly.

Sulphate of potash was not uncommonly used from 1894 to 1898, about one brand in six containing this salt. A similar proportion carried it from 1901 to 1906. Last year and this, however, but a bare half dozen brands have contained sulphate, yet inferentially its use is declared in three-fifths of the brands sold.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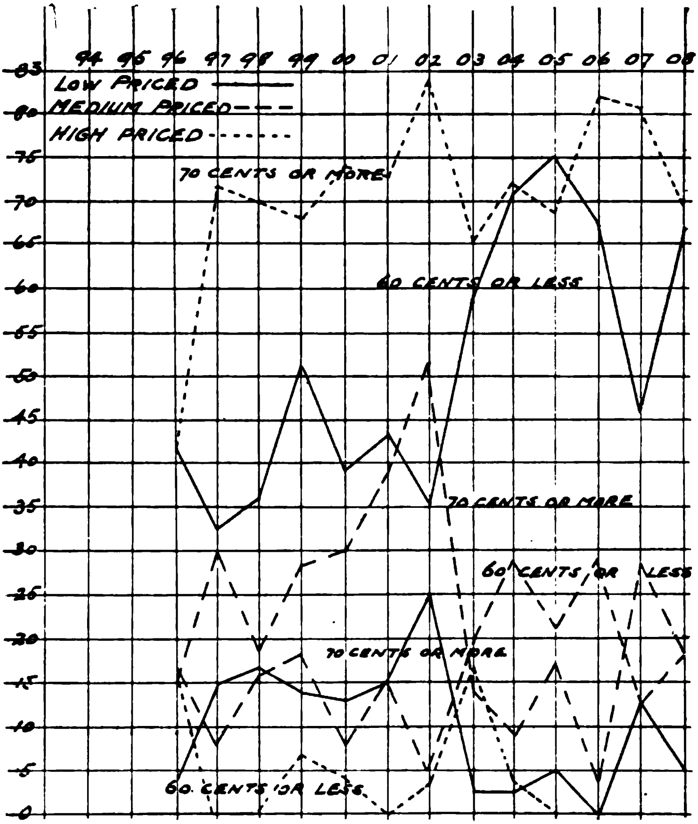
MEDIUM PRICED
LOW PRICED
HIGH PRICED
LOW PRICED
MEDIUM PRICED
HIGH PRICED
HIGH PRICED
MEDIUM PRICED
LOW PRICED

CHART VIII

The relative values of low, medium and high priced goods. It is one of the most encouraging things in the entire survey to note the trend of the three lines near the top of Chart VIII; to note how the low priced brands, relatively many in number in 1896 to 1900, are now relatively fewer; to note that the medium priced ones have practically exchanged places with them; and to note on the whole the uptrend in the number of high priced goods offered. These lines simply indicate the proportions of these various sorts offered for sale. No means avail for determining the usage of the several grades, but there is reason to believe from information at hand but not reducible to figures that the usage of low grades is relatively decreasing. The increased selling prices of the low grades from 1901 to 1903, coincident with the lowered prices put on the medium and high grades, were doubtless a main factor in the change. The increased number of high grades, despite the sharp increase in price, is an interesting fact.

The lower lines are interesting. Their parallelism is to be expected. The thrifty buyer of plant food should note that there are no crossed lines, that low priced goods always carry less plant food values per dollar paid out than do the other grades; and that high priced goods carry more, likewise without exception. The wideness of the gap between the medium and the high lines of 1903-1906 is significant.

NOTE.—*The figures on the left hand margin mean 60—15=%; 26—24, 30—28, 37—34= selling price; 75—55= cents worth of plant food bought for a dollar.*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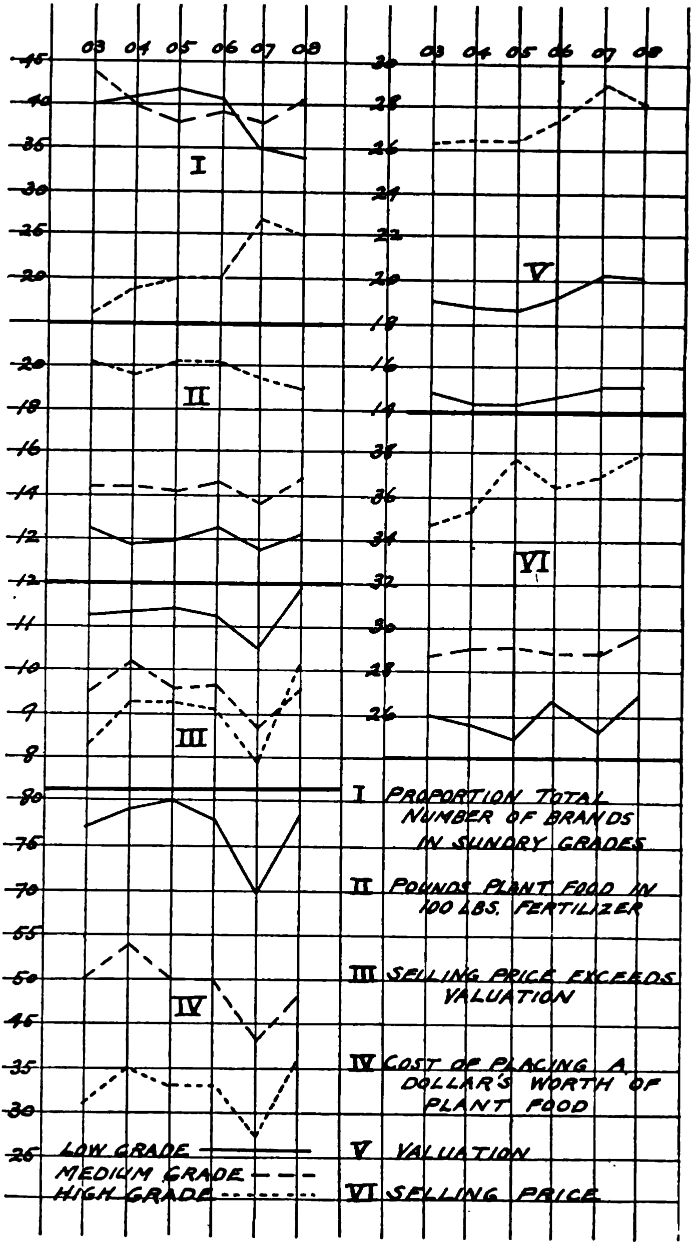
LOW PRICED ———
MEDIUM PRICED— — —
HIGH PRICED- - - - - -
70 CENTS OR MORE
60 CENTS OR LESS
70 CENTS OR MORE
60 CENTS OR LESS
70 CENTS OR MORE
60 CENTS OR LESS

CHART IX

The proportions of the sundry grades wherein 60 or 70 cents' worth of plant food were bought for a dollar. This chart is much the most blind of the entire lot—and inevitably so. However, it is not necessary for the reader to unravel its intricacies to gather its meaning. Note the dotted lines, representing the high priced goods. The upper one is far above all others, the lower one well below all others. The one indicates the fact that a larger proportion of these brands than of any other sort furnish 70 cents or more of plant food for a dollar spent; the other that less proportionately carry as little as 60 cents' worth for a dollar spent. Note the solid lines representing the low priced goods. From 33 to 75 percent afforded not more than 60 cents for a dollar; and from 25 to 0 percent afforded 70 cents for a dollar. The chart is weirdly obscure; but the lesson it teaches is simple and the moral plain.

NOTE.—*The figures on left hand margin indicate cents worth of plant food bought for a dollar.*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I
II
III
IV
V
VI
I PROPORTION TOTAL NUMBER OF BRANDS IN SUNDRY GRADES
II POUNDS PLANT FOOD IN 100 LBS. FERTILIZER
III SELLING PRICE EXCEEDS VALUATION
IV COST OF PLACING A DOLLAR'S WORTH OF PLANT FOOD
V VALUATION
VI SELLING PRICE
LOW GRADE ———
MEDIUM GRADE – – –
HIGH GRADE ·········

CHART X

The value of commercial fertilizers. The calculations on which this chart is based were first made in 1903. It would be possible to make them for part of the data back to 1887; but other portions, notably selling prices for earlier years, are not at present accessible. Hence it has not seemed necessary to undertake the large amount of work needed to get as an outcome only fragmentary data.

Grading the goods according to value rather than according to the price asked, which may or may not bear a logical relation to actual worth, one finds for the past six years:

1. Rather less low and medium grades and rather more high grades sold in the latter years.

2. More and better plant food sold in high grade than in medium or low grade goods.

3. A much higher selling price for high grades than for low or medium and for medium than for low, but;

4. Much greater valuations for high as compared with medium and for medium as compared with low grades.

5. Hence one finds that the difference between selling price and value is greatest in the case of the low grade goods and least with the high grade.

6. And that to place a dollar's worth of plant food in the farmer's hand it costs from 69 to 80 cents with low grade, from 43 to 54 cents with medium grade, and never more than 35 cents with high grade goods.

He who buys low grades pays money for mixing, bagging, freighting and selling make-weight or filler, that is to say materials carrying no plant food.

Twenty-five years ago the trade was in a way under a cloud, its products suspected, and penalties, severe even to harshness, were imposed by law. To-day it is well established and better regulated than are most trades, its products are better made and more standardized, more intelligently bought and more wisely and widely used. There is much yet which is far from ideal in its conduct, many absurdities as to brand names and their multiplication, as to claims and counter claims, as to the usage of make-weight, etc.; but as a whole it may be conservatively stated to be a trade conducted along honorable lines and of much service in modern agricultural operations.

SUMMARY

A fertilizer control has been conducted in Vermont since 1882. Before the system was inaugurated fertilizers contained no potash, were very irregular and uncertain in composition, were costly and fraud was rife. To-day the trade is systematized, brands are relatively uniform year after year, and seriously deficient fertilizers are uncommon.

A series of charts show for the successive years 1883-1908 inclusive:

I. The changes in trade values for nitrogen, available phosphoric acid and potash.
II. The maintenance of guaranties by licensees.
III. The excesses of plant food and of money values offered over those guaranteed.
IV Average analyses.
V. Average selling prices, valuations, excess cost over valuation, and values received for a dollar spent.
VI. The cost of plant food in Vermont.
VII. The soluble nitrogen and available phosphoric acid contents and the sulphate of potash usage.
VIII. The relative values of low, medium and high priced goods.
IX. The proportion of the sundry grades wherein 60 or 70 cents' worth of plant food were bought for a dollar.
X. The value of commercial fertilizers.

I. The nitrogen curve is a sag, high in the mid-eighties, and at present, and low in the mid-nineties; that of available phosphoric acid a rapid downwards slope to the mid-nineties and a nearly level line since; that of potash a nearly straight line for 25 years.

II. Guaranty maintenance is to-day poorer than it was ten years ago, but as good as it was twenty years ago.

III. Manufacturers are less liberal with plant food to-day than formerly, yet if guaranties are maintained nothing more can be asked.

IV. As the years have passed the tendency has been to lessen nitrogen and phosphoric acid contents and markedly to augment that of potash.

V. Selling prices dropped until 1902, since which time they have increased. Valuations, percentages of costs over valuation and the amounts of plant food bought for a dollar have varied, but speaking broadly, the situation was most favorable to the buyer fifteen to twenty years ago.

VI. Plant food has varied in cost; phosphoric acid has lowered in price; potash shows a convex curve, nitrogen an irregular line.

VII. Fewer brands carry nitrate nitrogen now than ten years ago, but the proportion of nitrate in those brands which carry it has increased; buyers get less of a less available phosphoric acid to-day than formerly; and sulphate of potash once used in 20 percent of the brands is to-day used in but 2 percent.

VIII-IX. The low priced goods are relatively lessening in number; the high priced increasing somewhat; while the bulk of the trade is made up of medium grade goods. The cheaper the goods the most costly the plant food; the higher the price the less the plant food costs; this year, last year and every year.

X. To place a dollar's worth of plant food in the buyer's hand costs from 69 to 80 cents when low grades are purveyed; 43 to 64 cents when medium grades are sold, and never more than 35 cents when high grades are handled.

VIII. SOIL DETERIORATION AND SOIL HUMUS

INTRODUCTION

It is a settled policy at this Station yearly to "feature" some special topic in its main annual fertilizer bulletin. The law provides for the publication of "information in relation to the character, composition, value and use" of fertilizers. A somewhat complete survey of matters in close "relation to" the purchase and use of fertilizers has been made in recent years. Analyses have been printed, comparisons with guaranties instituted, and the relationship of selling prices and money values of the plant food contents discussed; valuations, guaranties and their meaning, brand names and their lack of meaning, the nature, sources and functions of the deficient elements of plant food have been considered; the several brands have been classified; the character, composition, application and use of farm manures have been reviewed; the systems and methods which prevail in the use of plant food have been outlined, and suggestions offered as to amounts and kinds for sundry Vermont soils and crops. All this has been done in the hope that such a survey might aid in placing Vermont farm practice upon a higher plane and a more rational basis. While it is necessary yearly to make and to print analyses and to comment thereon, and advisable annually to discuss the financial phase of the proposition, the special features of bulletins 93, 99, 108 and 116 (1902 to 1905) do not need repetition, at present at any rate, since these bulletins have been widely distributed and are still available on demand.[1]

The more obvious and immediate matter "in relation to" fertilization having been covered, it seemed fitting year before last to begin to review matters less closely connected therewith; to pass from the consideration of artificial means of soil betterment to that of natural ones. Consequently the moisture relations of the soil, particularly as regards water control, through irrigation, drainage and adequate tillage operations, were discussed at length in the 1906 bulletin, No. 123. And, in pursuit of the determination expressed therein, to discuss "sundry phases of soil management during the next few years," a review was made last year of soil biology as it relates to fertilization and particularly to the soil nitrogen content, effort being made to present the matter in as readable and popular a manner as possible without the sacrifice of essential accuracy of statement.

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[1] Bulletin 116 is largely called for but is available as a loan only, the edition being nearly exhausted.

In further pursuit of this determination it has seemed particularly worth while, in this year and season which sees the first conference of the governors of the several states at the White House as to the conservation of the nation's natural resources, to consider somewhat in detail the causes and remedies of soil deterioration; to discuss methods of renovation; and to indicate ways by which further soil treatment may improve rather than impoverish; all this with special reference to the humus content of the soil and its maintenance. The statements of necessity overlap somewhat those hitherto made in bulletins 123 and 130, to which frequent reference is made, and are arranged under the following headings, viz.:

Introduction.—Pages 142-144.
Soil Deterioration.—Pages 144-153.
  The popular explanation.—Pages 145-147.
  Causes.—Pages 147-153.
    1. Erosion.—Pages 148-150.
    2. Nitrogen wastage.—Page 150.
    3. Moisture conditions.—Page 150.
    4. Soil texture.—Page 150.
    5. Bacterial conditions.—Pages 150-151.
    6. Shortage of available plant food.—Pages 151-152.
    7. Soil acidity.—Page 152.
    8. Humus.—Page 153.
The Soil Humus Content.—Pages 153-175.
  Definition.—Pages 153-155.
  Benefits of humus to soil.—Pages 155-158.
    1. As a nitrogen supply.—Pages 155-156.
    2. As a mineral plant food supply.—Pages 156-157.
    3. As a storage of water.—Page 157.
    4. As a source of warmth.—Pages 157-158.
    5. As an improver of texture.—Page 158.
    6. As an aid to micro-organic growth.—Page 158.

Effect of shortened humus supplies.—Pages 158-160.
  (a) On the individual farm.—Pages 158-160.
  (b) On national well being.—Page 160.
Diagnosis of humus lack.—Pages 160-161.
Soils which need humus.—Page 161.
Effects of current agricultural methods.—Pages 161-164.
  (a) Continuous cropping.—Pages 161-163.
  (b) Inadequate rotations.—Pages 161-163.
  (c) Fallowing.—Pages 163-164.
  (d) Deforestation.—Page 164.
  (e) Forest or other fires.—Page 164.
  (f) Continued usage of commercial fertilizers.—Pages 164-165.
Maintenance and increase of soil humus supplies.—Pages 165-175.
  (a) By crop rotation.—Pages 165-167.
    The theory of soil exhaustion.—Pages 165-166.
    The theory of soil excretion.—Pages 166-167.
  (b) By farm manures.—Pages 167-168.
  (c) By green manuring.—Pages 169-175.
    Benefits.—Pages 169-171.
    Crops used.—Pages 171-173.
    Practice.—Pages 173-175.
Summary.—Pages 176-177.

SOIL DETERIORATION

Inquiries as to the proper solution of specific soil problems are common at all Experiment stations. Answers must needs be couched in general terms since circumstances alter cases and since these usually are inadequately described by the inquirer. To such an one, however, a general statement as to the modern conception of the broad proposition of soil renovation is often suggestive and serviceable; and such this article is meant to be. Its application to the individual case is the task of the interested party, whose request for more detailed or specific information the Station will be always ready to consider.

The following inquiries, culled and condensed from recent correspondence, are exhibited as types of the class of queries received, to the answer of which it is hoped this presentation may be of service.

1. What is the best fertilizer for light soils?

2. How may old pastures best be brought into good working order?

3. What fertilizer or other soil treatment is recommended for oats and seeding down on sandy loam?

4. My farm is clay loam in good tilth; would it pay to use either or all of the following: nitrate of soda, acid phosphate, muriate of potash? Ashes are beneficial. I top dress annually with ten loads of manure or more per acre.

5. My soil is a clay loam, with clayey subsoil; cuts but little hay; and is somewnat mossy; was in meadow for 25 years; plowed in 1906 and 1907; sown to oats and seeded down; manured in part; ashes on part; three acres were planted to potatoes with 600 pounds medium grade fertilizer per acre. How shall I handle it for best grass returns? I have 500 pounds each of nitrate and of muriate and 1,000 pounds of ground bone.

All of these are but variations of the fundamental question: Why are soils which in our fathers' hands were productive now relatively impoverished? A question easily asked but hard to answer with entire satisfaction.

THE POPULAR EXPLANATION

It is usually said that the soil is exhausted, run down, worn out, and the popular notion is that its plant food content if not absolutely gone is at least reduced to a minimum. Those farmers who give thought to the matter are apt to say in general terms that the fertility of the soil is at a low ebb and needs renewal and maintenance.

This common conception of the nature of the difficulty and as to what constitutes "fertility" is incomplete. It over-emphasizes the chemical phase. Fertility and plant food are not synonymous terms. The dictionary gives no hint of plant food in its definition of fertility which reads "the state or quality of producing fruit, etc., in abundance; as the fertility of land or meadows." Fertility is a general condition, not one of its attributes. Plant food is only one, and often not its main, attribute. Moisture, warmth, and aeration; soil texture, soil fitness, soil organisms; its tillage, drainage and irrigation; all these are quite as important factors in the make up and the maintenance of the fertility of the soil as are manures, fertilizers, and soil amendments.

The crop producing power of a soil constitutes its fertility and not simply its content of three or four forms of plant food. And its maintenance involves such all-round soil handling as will conduce to maximum effectiveness. According to circumstances one lays stress on this, that or the other phase; accentuates the importance of tillage, dwells on the water content of the soil, points out the relationship of its humus content to soil conservation, advocates green manuring, preaches the clover cult, or swears by the manure pile or the fertilizer sack. Increasingly, however, emphasis is being laid on the direction of natural forces, on the conservation of inherent richness, on the acquirement of plant food supplies from air and subsoil. But the popular mind is still fixed on the idea that a fertilizer is the panacea. Every soil sample sent for analysis is accompanied by the request for information as to needed fertilization. The purchase of plant food is an important matter, but the use of a "phosphate" is not a cure-all, nor will it prove an adequate substitute for proper soil handling.

The popular mind usually assumes that the so-called abandoned New England farms have been deserted because of soil exhaustion. There are other reasons which have been powerful factors in this change, such as: The opening of western lands and opportunities since the middle of the last century; the development of new and profitable agricultural industries, ill-fitted to New England climatic conditions; the rigor of these conditions and the attractions of milder winter climates; the cost of maintaining and using the rough, stony New England fields in competition with the wide, fertile and stoneless areas of the West; the low freight rates on the grosser agricultural products from the West; the competition of the mills and factories for labor; the "voice of the city"; the trend of school education away from the farm; the decreasing birth rate of the old New England stock; lowered values for products, etc.[1] There are of course great differences in natural and original soil characters. There are soils and soils; soils which from the outset are relatively unproductive unless assisted; others which at first are fertile but rapidly become depleted; yet others which maintain a high degree of productivity for long years. The best of them show wear if improperly managed; yet even though wretchedly mismanaged a large share of soils now relatively impoverished may be renovated. To the end that the disease may be diagnosed and the remedy prescribed, let us review the causes of soil deterioration as a logical precedent to the consideration of means of its restoration.

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[1] It is not within the province of this article to discuss these economic and sociological causes. Such as are interested therein should get Report No. 70, U. S. Department of Agriculture, "Exhaustion and Abandonment of Soils," by Dr. Milton Whitney (1901), a thorough exposition of these causes and of the remedies therefor.

CAUSES OF SOIL DETERIORATION

Soils become impoverished in many ways, some natural, some artificial. The condition is sometimes remediable and sometimes not. Several of the causes are stated below, some of them being elaborated later, while others are not further discussed, having been reviewed in previous issues. The order of statement has no significance.

1. *Soils become surface washed by water or are wind blown.*—Pages 148-150.
2. *Unclad soils lose nitrogen* by nitrification, denitrification, and leaching.—Page 150; also bulletin 130, pages 236-244, 261-264.
3. *Soil moisture conditions may be faulty,* due to inadequate tillage, drainage, etc., page 150; bulletin 123, pages 171-180.
4. *Soil texture,* i. e. tilth, fitness, condition, is inferior.—Page 151; also bulletin 130, pages 225-264.
5. *Soil bacterial conditions are unsatisfactory.*—Pages 150-130, pages 225-264.
6. *The soil may lack available plant food in sufficient quantities.*—Pages 151-152; also bulletins 99, pages 88-104; 116, pages 173-186.
7. *The soil may be acid.*—Page 152; also bulletin 99, page 100.

8. *The soil may lack humus.*—Pages 153-175.

It will be observed that these eight causes of soil deterioration list as follows:

Inferior chemical condition, i. e. shortage of plant food, 2; Nos. 6 and 7.

Inferior physical condition, 4; Nos. 1, 3, 4 and 8.

Inferior biological condition, 3; Nos. 2, 5 and 7.

Soils are more apt to be "worn out" because of physical ill-condition than because of plant food shortage; a misfortune due mainly to ill-usage. The three prime remedies—there are others also—are:

1. To add humus—by adequate crop rotation;
2. To add humus—by the use of farm manures;
3. To add humus—by green manuring.

Reviewing now these several reasons for soil deficiencies in the order stated:

1. *Erosion, the surface washing or wind sweeping of soils,* is in many sections a grave problem. Every mud-laden stream bears evidence of destruction and betrays inadequate protection. Wherever field slopes are steep, the rainfalls torrential, the surface tillage other than level, the subsoil comparatively impervious, the surface soil relatively loose and readily moved; wherever the soil humus content is low, deforestation common, animal husbandry a minor industry, or green manuring not practiced; where crop rotations do not obtain and the one crop system is in vogue; in such regions and under such conditions, damage occurs. It is the best which is taken, the finer surface soil, bearing most of the weather worn and available plant food. The knolls, the high spots are denuded, leaving unproductive subsoil, gravel or ledges exposed. The great underlying reason why valleys are more fertile than are the uplands is that gravity and running water conspire to bear the finer particles down hill.

In its earlier stages apparently a minor matter, and its damage trifling, the multiplicity of the channels whereby wastage occurs makes for a larger totality. Gullies form here and there which in time widen and deepen until the face of nature is sometimes pitiably scarred and gashed. The Piedmont region of the South, where repeated crops of cotton have lowered the humus supply; sections of the far West, where close grazing has in part killed out the grass; Palestine, North Africa, Spain and other old world sections, fertile lands within historic times, now desolate assemblages of barren hills and swampy plains irreclaimable and useless; these are the "bad lands," made bad by man's mishandling. Nitrogen, phosphoric acid and humus are largely lost thus, particularly nitrogen and humus mostly located in the surface soils. Such soils once thoroughly denuded are reclaimed if at all with difficulty, and often the profit of the operation is doubtful. "An ounce of prevention is worth a pound of cure."

The relationship to this condition of deforestation of the one crop system, of agricultural methods which take no thought of the morrow and of the importance to that morrow of the maintenance of soil humus supplies, is fairly well understood; yet the warnings are largely unheeded. That the conditions above outlined do not obtain in New England to the severe extent that they operate elsewhere is due to its winter climate, its grass clad hillsides, its still considerable forests, its diversified cropping, its large animal husbandry interests. Erosion occurs here and is likely to increase in extent, particularly as the forests are swept away; and hence pointed reference may well be made to its bearing on soil devastation.

Forest preservation, forest planting, the guidance of flood waters and streamlets, and level culture are applicable everywhere, where erosion is and where it is not an important proposition; and in regions where the danger is imminent, terraces, sidehill ditches, the damming of gullies and the adaptation of tillage operations and implements to the situation are employed. A deep soil providing large chance for rain storage, on which deep rooting crops like the clovers are grown; a soil bound together with the dense mat of grass roots; the filling of the soil with humus by the use of farm manures, green manuring, or grass growing; all these are fundamental conditions which make for the control of erosion be it of wind or water.

2. *Unclad soils lose nitrogen* because of their inability when thus naked to catch and hold this fugitive element. The excessive nitrification in the fall, the losses from denitrification and kindred processes, the many non-bacterial sources of nitrogen escape, were dealt with at length in bulletin 130 (pages 236-268). Fortunately mineral forms of plant food are held more readily and drainage losses of phosphoric acid and potash are relatively minor matters. Continued soil occupation, the use of catch crops and the abandonment of the fallowing system are the proper procedures to lessen nitrogen losses.

3. *The soil may suffer from lack of, from excess of, or from inability to get at, water.* This proposition, more particularly as regards tillage and its relation to the water holding powers of the soil, was discussed at some length in bulletin 123 (pages 171-180). Other phases have been but briefly referred to in station publications and are reserved for future treatment.

4. *Soil texture* is determined by the size, shape and grouping of the soil particles. Just as a cloth may be closely or loosely woven, fine or coarse textured, so may a soil be open and porous like a sandy loam or close and impervious like clay. The physical character of the soil is in a general way inherent. One cannot turn sand into clay or vice versa. But one can modify them by the use of certain amendments or other treatments. Thus the coarse, leachy sands may be made more retentive by the use of humus crops or manures and the fine retentive clay rendered more porous by the same means, or by the use of lime to flocculate the soil particles. When the unsatisfactory texture is due to inadequate tillage, the soil lumpy, and hard to pulverize, the fault is more that of the handling of the soil than of the soil itself. In this connection see bulletin 123, pages 175-180.

5. *Soil bacterial conditions* may be below par for many reasons. Nitrification may be too slow or too rapid, nitrogen-

fixing organisms may be absent or inactive, or nitrogen elimination a menace. All of which and more were discussed in full in bulletin 130, pages 226-264, and need here no further mention.

6. *The lack of available plant food* in quantities sufficient to produce adequate returns may be due to inherent poverty (rarely), to misuse, or to under-use. If naturally lacking, extraneous supplies must be obtained, in which event the system of experimental home trials outlined on pages 174-177, bulletin 116, if inaugurated ought to indicate what form or forms are lacking and lead to a more rational and economical fertilization. If plant food is present but its availability low, it may be either supplied or developed by the purchase of commercial goods on the one hand, or the use of manures, green manures and adequate tillage operations on the other. The inherent richness of even the poorest soil is more than many imagine. The content of the deficient elements of plant food in the upper eight inches of a "worn out" soil mounts into the thousands of pounds. Thus in a table showing fifteen representative soils the nitrogen content but once sinks below 1,100 pounds and but twice below 1,500 pounds; the phosphoric acid content, but once below 1,000 pounds and but thrice below 1,500 pounds; while the two lowest potash contents are 1,000 and 1,200 pounds, and the next lowest 4,000 pounds. Their average contents were in excess of 3,000 pounds nitrogen, 5,000 pounds phosphoric acid, and 17,000 pounds potash in the upper eight inches; and these figures are less than those usually exhibited as averages. Then again the next eight inches, more or less open to the use of most farm crops, carry usually nearly as much phosphoric acid and potash as do the upper eight inches.

Compare with these totals the drafts of crops. A two ton per acre hay crop might use up the soil nitrogen—if it could get it all and in the meantime no increments occurred through clover growth, or through bacterial or other agencies—in fifty years; but 275 years would elapse before the potash gave out and over 350 years before the phosphoric acid became exhausted; and these from the surface eight inches only. The drafts on the total plant food are relatively small; but those on the available forms thereof may be large. Then, too, there are drafts on the soil other than those made by crops. Hence such speculations have academic rather than practical interest. Yet they serve to show that soils are not denuded of plant food in totality, but that the causes of lessened crops may be in part at least due to soluble plant food shortage; for these large amounts are almost entirely insoluble and but slowly made available through weathering processes and tillage operations.

However, other causes affecting soil texture are quite as apt, or more so, to be at fault; and they may be remedied by tillage, drainage, rotation, green manuring, and the use of manures. These constitute the best keys for the unlocking of unavailable plant food; tillage to increase the fineness of the soil particles and to promote the solubility; drainage to augment soil aeration and root penetration; rotation to bring diverse rooting habits to bear upon soil particles; manuring, green and farm, to promote solution by chemical and biological action. However, the farmer is more concerned with the "immediate producing capacity" of the farm than with the "permanent productive value" of the soil. The exhaustion of soils is rarely if ever due to the serious depletion of the latter, but to the reduction of the former to such a condition that its use is unprofitable; in which event fertilization is resorted to as a means of gaining profit.

7. *The soil may be acid.* Such soils are not adapted to the better forms of crop growth. The acidity may be due to natural causes, to either a lack of or an excess of humus, to over-usage for a series of years of commercial fertilizers, to leaching of lime from porous soils, etc. Wherever the growth of beets is markedly augmented by the use of lime, acidity is quite certain. Wherever the litmus paper test (blue litmus paper—at any drug store—placed in a mud pie made of clean rain water and the suspected soil, turning red as a result of the acid) shows red, acidity is probable. Ashes or lime sprinkled on the plowed furrows and harrowed in will tend to sweeten the soil. See bulletins 99 and 130.

8. *The soil may lack humus,* its distinctive plant food bearing organic matter. The maintenance of soil fertility is largely a matter of the upkeep of its humus content. The "first aid to the injured" soil, abused and worn out, usually should be to supply ample quantities of a good quality of humus. Hence a considerable review of this matter is in order.

SOIL HUMUS

Not all the organic matter of the soil is humus. It is of three sorts, the living, the dead and the very dead. In the first class are listed the various forms of animal life, earthworms, insects, moles, etc.; the living roots of higher plants; and the sundry forms of micro-organic life, fungi, molds, bacteria, discussed at length in bulletin 130. The undecayed or barely acted upon stubble, roots of recently harvested plants, constitute the second division; while the third class is made up of the decayed and decaying remnants of the second as acted upon by certain agents listed under the first head. It is this mixed animal and vegetable matter—mostly the latter—in its intermediate forms of decomposition, far along but not complete, which constitutes humus; a variable, indefinite sort of a thing, difficult to classify chemically, complex, sometimes highly nitrogenous, again nearly nitrogen free, the residues of the decay of cellulose, lignin, starch, sugar, proteids, fats, etc.

Decomposition was discussed at some length in bulletin 130 (pages 229 to 236). It was there stated that "the result of the partial decomposition and putrefaction of the organic matter of the soil, leaves, sticks, stalks, straw, stubble, sod, roots, green crops turned under and the like, is humus," which was defined as being "mostly decayed—not decaying—vegetation, a black loose mold in which the stem, leaf, etc., structure is destroyed. In the glossary it is defined as "a black or brownish soil ingredient the resultant of vegetable decay; vegetable mold. Vegetable matter decaying is not, vegetable matter decayed is, humus." Yet when that process has progressed to its ultimate end the humus itself is destroyed and resolved into the simple molecules of ammonia, nitric acid, elemental nitrogen, carbonic acid gas, marsh gas and water. Humus, then, is an intermediate product. It is neither the freshly dead but undecayed leaf or other organic matter, nor is it its final gaseous products. It is material which has undergone not only the initial but most of the medial stages of decomposition, which in its final process of decay furnishes certain forms of plant food to plants. During its process toward final destruction, while being made into mold, it is useful to the soil. Moreover, during its formation and its decay it exhibits effects other than chemical, having relation to the warmth, color, moisture holding capacity, texture, to the tillage and the biological activities of the soil.

Once extolled as the essential soil ingredient, the bright particular star in the firmament of the plant grower, it fell like Lucifer when the agricultural chemists of the second quarter of the last century demonstrated the aerial origin of the major part of the plant structure. Yet to-day it is highly esteemed again in view of the results attained both by practice and science. It is now recognized to be not the, but an, essential soil constituent, and experimentation has shown the underlying reasons for the well understood fact that soils rich in humus are usually productive and explained why it is that farm manures are more effective than their plant food contents would indicate.

Humification is a variable process. It may progress rapidly or slowly, largely according to temperature conditions. Thus the arctic tundra is preserved indefinitely and the peat bogs are common in Iceland. On the contrary in the tropics the process is greatly accelerated, peat is unknown, and vegetation rank, largely because of the rapid decay and availability of the plant food furnished by its predecessors. The main controlling conditions are the amount of moisture, the presence of air, the temperature and the number and kind of soil bacteria, fungi and molds (see bulletin 130, pages 229 to 232). The result is a more or less steady progress either toward simple and gaseous molecules and complete destruction, or, in lack of access to air and of conditions causing pressure, the slow formation through the ages of peat, lignite, bituminous and anthracite coals. According to circumstances humification may tend in one direction or the other; but the latter rarely if ever occurs under soil conditions. The chemical substances produced are many and often complex, including diverse humus acids and salts, humates, ulmates, etc. The nature of the ultimate product of course varies somewhat. Thus starch and sugar tend to make sour humus, while debris rich in protein furnishes a more nitrogenous humus. Hence soils carry not only different quantities but also different qualities.

The quantity of humus in a soil may range from one to twenty or more percent. The usual range in humid regions is from one to five percent. Meadows and forested areas usually carry relatively more and long cultivated areas relatively less humus. The former tend to increase their humus content owing to the leaf mold, root areas, etc.; the latter to decrease it owing to crop removal, to more complete soil aeration and consequently more rapid humus oxidation and destruction. Hence the necessity of manuring cultivated soils, or of rotating crops, procedures which are unnecessary in forest or grass areas.

A review of the chemical and physical effects of humus on soil culture with a discussion of the bearing of current agricultural methods thereon, and of the means of the adequate maintenance of the soil humus supply, seem now in order.

Humus benefits the soil chemically:

1. By supplying nitrogen directly;
2. By supplying phosphoric acid, potash and lime indirectly.

It benefits the soil physically:

3. By augmenting its water holding capacity;
4. By increasing its warmth;
5. By bettering its texture.

It benefits it biologically:

6. By affording food materials for micro-organic growth.

1. *Humus as a supply of nitrogen.*—The available nitrogen

of the soil, other than that captured from the air, is of humus origin. This is the raw material from which nitrates are formed. Some sorts carry more nitrogen than others, are large purveyors of that element, active in their effect on the mineral plant food of the soil, and are not apt to be sour. Others, derived from starch or lignite, are nearly nitrogen free, are apt to be relatively inert, less likely to promote mineral availability and more prone to acidity. Snyder[1] reports a sawdust humus as carrying 0.3 percent nitrogen, and one derived from red clover, 8.2 percent. The humus content of the soil and likewise its nitrogen percentage lessen with increasing depth; the former because of the location of the roots, the latter because of diminished oxidation of the carbon and hydrogen.

2. *Humus as a supply of mineral plant food.*—Acids are formed during humification capable of dissolving more or less mineral matter. It is a moot point whether the potash, lime, and other mineral forms of plant food are or are not chemically combined with the humus as humates, although the weight of evidence seems affirmative. However, whether combined or not, they nourish plant life; and it seems probable that they become available to this purpose through the agency of the humus compounds. Snyder[2] shows that the ash from a prairie soil humus may carry 7.5 percent potash and 12.4 percent phosphoric acid, equivalent to 1,000 pounds of potash and 1,500 pounds of phosphoric acid per acre in a soil carrying total quantities of 12,250 and 8,750 pounds respectively. Obviously through the long ages the humifying process in the rich prairie soils had served to render available very large proportions of these two ordinarily deficient forms of plant food. And yet even these supplies do not last forever. (See page 159). The value of these humus mineral combinations as plant food has been experimentally demonstrated and is practically attested by the rooting habits of

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[1] Minn. Sta. Bul. 53, pp. 18, 22 (1898).

[2] Minn. Sta. Bul. 53, p. 32 (1898).

plants as related to manurial supplies, former crop residues, etc., as well as to the vegetation occurring on such organic residues as rotting sawdust heaps and peat bogs.

3. *Humus as a storage of water.*—Humus is sponge-like in its water absorbing powers. Organic matter of all kinds holds water better than does mineral matter; and decaying organic matter does not, because it is decaying, lose this power. Peat is said to be capable of absorbing six times its weight of water, dry sawdust four times, straw two to three times, leaves one and two-thirds times, and vegetable mold a half its weight of water. A soil well supplied with humus may hold nearly twice the water that a medium sand will carry and half as much again as a medium sandy loam. And plants use from 250 to 800 times their dry weight of water during the growing season. Not only is moisture thus absorbed and tightly held as against drainage losses, but humus assists the capillary rise of water, thus promoting crop growth in droughty seasons, the moisture being more slowly and evenly conveyed to plant roots. The relationship of this property of humus to the well being of vast sections of country is well understood, yet, alas, often disregarded. The relationship of effect to cause may be clearly traced. Millions of dollars' damage is caused by floods, due to an inadequate supply of humus in the soils of upstream regions caused by forest removal, the continued cropping of the soil, too little use of grass in rotation, etc. The presence of ample humus supplies in the soil spells success; its lack means disaster. The water holding capacity of a soil may be lowered a quarter by reducing its humus content by half. Once lowered it may in some measure again be restored by restocking the soil with humus. Better absorption of rainfall, better drainage, better capillary water movement, higher soil moisture efficiencies; all these good things does humus bring about.

4. *Humus may warm a soil.* Black clothes are warmer than white ones, since the one tends to absorb and the other to reflect heat rays. Similarly dark soils, other things being equal, are apt to

be warmer than light colored soils. And humus, in humid lands at any rate, usually tends to darken the color of the soil. Then, again, decay is in part an oxidation process and oxydizing carbon, whether in a stove, a manure heap or in decaying roots, evolves heat. Between these two sources of heat, absorbed and evolved, the dark soil may be appreciably warmed, the crop made thus the earlier and fall frost injuries warded off. But it may happen that there is so much humus present as actually to cool the soil; for since water is slow to evaporate and tends to cool a soil, much humus may mean much water, and the cooling effect thus induced overbalance the temperature increment.

5. *Humus betters soil texture* and improves its handling. The porosity of humus and its shrinkage during decay is such that soil aeration is bettered. It lowers the weight of the soil, since humus is the lightest of soil constituents. These two factors, increased pore space and lessened weight, tend to promote easier tillage. Sandy soils are made more compact and retentive; clay soils made more mellow and porous. This easier tillage, however, itself tends to destroy that which makes it easier, that is to say clean culture serves rapidly to deplete soil humus supplies.

6. *Humus aids the growth of micro-organisms,* as discussed on pages 229 to 232, bulletin 130.

Several questions now need answer:

1. Is it a very serious matter if a soil is relatively lacking in humus?
2. How may one diagnose shortage?
3. What kind of soils are most apt to need added humus supplies?
4. What are the effects of current farming methods on the humus supply of the soil?
5. How may one proceed to maintain or to augment it?

I. THE EFFECT OF A SHORTENED HUMUS SUPPLY

(a). *On the individual farm.*—The proverbial richness of virgin and prairie soils is due largely to the accumulated humus of past centuries. The westward trend of soils of "inexhaustible fertility," the westward passage, even to the Pacific Coast and the Hawaiian Islands, of the fertilizer agent, and the enactment of fertilizer laws in states west of the Mississippi; all these tell the story of the destructive effect of tillage and the cropping of virgin soils. Snyder's[1] famous table epitomizes the situation perfectly as follows:

Influence of different systems of farming on the chemical and physical properties of soils:

	Cultivated for years	How	Productiveness	Weight per cubic foot	Humus	Nitrogen	Phosphoric acid	Water holding capacity
				lbs.	%	%	%	
1.	35	Rotation and manures,	High,	70	3.32	0.30	0.04	48
2.	35	Continuous grain,	Low,	72	1.80	0.16	0.01	39
3.	42	Rotation and manures,	High,	70	3.46	0.26	0.03	59
4.	35	Unsystematically,	Medium,	67	2.45	0.21	0.03	57

Numbers one and two were on adjoining farms. Number one has rotated wheat, corn, oats, timothy and clover and there was no apparent decline in yields. Number two had dropped in 35 years from 25 to 8 bushels of wheat per acre. Its humus was almost half gone and it had but three-fourths its original water holding power. Numbers three and four were on the same farm. Number three was systematically rotated for 42 years; the other grew wheat and oats and corn, with an occasional crop of grass for 35 years; yet the former after seven years' more usage was in distinctly better condition.

That such shrinkages are not due solely to plant food shortages is attested by the relatively meagre returns often resulting from the use of commercial fertilizers. That the loss of humus is a main cause of the shrinkage is proved by such data as is exhibited on page 159, for grass adds to the humus supply while grains and hoed crops generally lessen it. Moreover the fact that by the establishment of rational rotations, green manurings and the use of manures an approximation to virginal fields may be again attained, is further evidence of the accuracy of the thesis that as between old worn-out soils and new soils of the same general character the main important difference is their humus content.

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[1] Minn. Sta. Bul. 53, p. 28 (1898); also U. S. Dept. Agr. Year-book for 1895, p. 141 (1896).

(b). *On the well being of mankind as a whole.*—One of the deep, underlying, fundamental propositions which brought together the first conference at the White House of the governors of the several states of the Union in May, was the depletion of the humus content of American soils. It was not so worded, but such was the fact. Deforestation and wasteful methods of agriculture and manufacturing operations; the washing and gullying of soils in the cotton states, where whole townships of the best upland soils have become sandy and irreclaimable wastes; the bad lands of the far west, overstocked with sheep and washed away by torrential rains; the destruction of pastures and meadows; the periodic torrents which, running off bare mountain slopes, flood the lowlands, yet are dry during most of the year; all these are mute but eloquent evidence of the relationship of a shortened soil humus to man's well being.[1] For all these conditions are brought about by this one cause resulting in several ways. Obviously the first question may be answered affirmatively. Soil humus shortage is a serious matter.

2. HOW MAY IT BE DIAGNOSED?

One may tell the fact:

(a) By his general knowledge of the past history of the soil.

(b) By observing the relative effects thereon of farm manures and of commercial fertilizers.

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[1] See pages 148-150 on erosion.

(c) By its tint when wet, for if it fails to darken somewhat when moistened, it is likely to be lacking in humus.

3. WHAT SOILS NEED HUMUS?

The looser, more thoroughly aerated soils lose humus more readily than those which are compact. They become oxydized and destroyed, often to such an extent that they suffer wind erosion. Hence sandy loams and sands, particularly if long cultivated in a non-rotative way or if ill-supplied with manure, respond well to humus supplies. Clay and clay loams are apt to be bettered mechanically by its use, particularly as regards the porosity and aeration, but stand in no such desperate need of amendment. Swampy or muck soils or dark, virgin prairie soils do not need it; but outside of these there are but few sorts to which humus additions may not prove advantageous.

4. WHAT ARE THE EFFECTS OF CURRENT AGRICULTURAL METHODS?

The humus supply of the soil is lowered by:

(a) Continuous growth of tilled crops.—Pages 161-163.
(b) Rotative cropping without using grasses or legumes.—Pages 161-163.
(c) Summer fallowing.—Pages 163-164.
(d) Deforestation.—Page 164.
(e) Forest or other fires.—Page 164.
(f) Continued usage of commercial fertilizers.—Pages 164-165.

It is augmented by:

(a) Crop rotation.—Pages 165-167.
(b) Farm manures.—Pages 167-168.
(c) Green manuring.—Pages 169-175.

(a and b). *Constant cropping or rotative cropping without grass or clover* in the rotation draws unevenly on the plant food content and continually on the humus. Conditions of clean culture tend rapidly to "burn out" the humus, to promote inordinate putrefaction and consequent drainage losses (see page 266, bulletin 130). Thus in the case cited on page 159 the 0.14 percent loss of nitrogen is equivalent to some 3,500 pounds of nitrogen, perhaps a quarter of which was used by the crops and the rest lost by drainage, denitrification and other processes of elimination. As with nitrogen so with phosphoric acid, potash and lime, but to a less extent.

Different crops make diverse drafts from the soil constituents, some drawing heavily, some less so. The minimum drafts per acre of twenty-four crops, including all the more common ones, as given by Van Slyke,[1] translated into monetary form, using the trade values of commercial fertilizers for 1908, varies from $3.36 an acre (grapes) to $27.64 per acre (cabbage). Among the more common crops may be cited: apples, $7.11; clover hay, $10.64; corn (kernels only), $9.97; mixed hay, $7.34: oats, $7.65; potatoes, $5.10; timothy hay, $6.81; tobacco, $12.36; wheat, $7.31. The drafts in terms of plant food varied from 7 to 100 pounds of nitrogen, from 2 to 35 pounds of phosphoric acid, and from 13 to 135 pounds of potash. It goes without saying that even minimum drafts cannot go on forever without restitution save with the result of yet greater dearth. The continuously cropped fields of Rothampsted, unmanured for fifty or more years, yielding now for many years a low and almost unchanging and unprofitable minimum, plainly tell the story of the ultimate outcome of the continued use of the one crop system.

The husbandman who is concerned not only with the immediate gains but also with the continued usefulness of his farm, will keep some track of the plant food outgoes and will try so to adjust his procedure as to increase the plant food content of his soil if possible, at any rate to maintain its status, or at worst to minimize the losses. To that end let us scan the effects wrought upon the plant food content of the soil by different classes of farming operations.

Grain farming.—The sale of nitrogen, phosphoric acid, potash and lime from the farm.

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[1] N. Y. (State) Sta. Bul. 94, p. 344 (1895).

Mixed grain and stock farming.—Ditto; gain of plant food from legume growth for stock and possible purchases. Losses (grain, stock, milk) are apt to exceed gains.

Stock farming.—Sale of stock induces plant food loss which may be more than made up by clover growth and proteinous grain purchases.

Dairy farming—The losses from milk and milk products sales may be estimated as follows: A twenty-cow dairy, averaging yearly 4,000 pounds of milk apiece, would denude the farm by the sale of dairy produce: If milk is sold, of about $99 worth of plant food; if cheese is sold, of about $67 worth of plant food; if butter is sold, of about $1 worth of plant food; provided in the latter two cases the whey or skimmilk and buttermilk are fed at home. The increments from legume growth and concentrate purchase make dairy husbandry an attractive proposition as viewed from the standpoint of soil fertility maintenance.

All this argument, valid though it is, should not be construed as conclusive against the one crop system in every contingency. Specialization of crops is often the very best possible practice. Tobacco, onions, certain market garden crops, may be thus grown and grown successfully when adequate provision is made for the restoration of removed plant food and the maintenance of the humus content. The argument is meant to point out the limitations and dangers of the procedure, not to indicate that its practice may not at times be profitable; and, further, to suggest that not infrequently when single cropping has been in vogue, rotative cropping may be followed to equal or greater advantage. The quickest way to rebuild a poor soil is to practice dairy farming, growing forage crops, buying the right sort of grain rich in protein, handling the manure properly, and returning it to the soil promptly. No other type of farming is as successful to this end. And this is why Vermont buys less commercial fertilizer to the improved acre than does any other state east of Illinois.

(c) *Fallowing* was once the vogue. It is still practiced in the far West, particularly in arid and semi-arid regions. It tends to promote weathering, to augment the surface supply of available plant food, to increase water storage, particularly in the dryer regions, and to aid in the combat with weeds (summer fallowing), a reason which appeals to many New England farmers. But in humid lands where the husbanding of each rain drop is not a vital matter its practice is followed by serious nitrogen losses (see bulletin 130, page 260). A Minnesota soil fallowed for a year lost five pounds of nitrogen for every one made available.[1] A penny wise, pound foolish proposition, temporarily helpful and permanently harmful, it is to be decried, as is also that far more common eastern custom, non-occupancy of the soil after the September harvest.

(d) *Deforestation.*—That tree cutting lessens the humus supply is so self-evident as to need no argument. The forest mulch of leaves and litter, deep, rich, omnipresent in forest areas, a potent factor in the control and regulation of the run-off of rains, can only be found where trees abound, and does not long last when their protection is removed. As preventers of air and water erosion, as absorbers of rainfall, and regulators of the stream flows, forests are paramount.

(e) *Forest and other fires* do damage other than the obvious destruction. The burned over soils are apt to lose from half to three-fourths of their nitrogen contents, because of the burning of the leaf mold humus. It is well known that forest fires creep along in the so-called "duff" and, after the passage of the main conflagration, live therein as a dull smoulder for a long time. Grass fires are less destructive, yet do some damage.

(f) *The continued use of commercial fertilizers* tends towards the exhaustion of the humus. They supply little or none. Their function is to augment crop growth, which means the usage of humus. If attempts are made to maintain soil productivity by their use alone, special measures looking toward the upkeep of the humus content have to be resorted to or else deterioration in this respect occurs. This is no valid argument against the usage of commercial fertilizers, but constitutes a plea for their proper usage in connection with and not continuously in lieu of humus yielding materials.

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[1] Snyder, Minn. Sta. Bul. 58, p. 10 (1898).

5. HOW MAY ONE MAINTAIN AND AUGMENT THE SOIL HUMUS SUPPLY?

One may maintain and augment the soil humus content by three procedures, all practicable, all standard and long practiced, viz.: (a) crop rotation, (b) the use of farm manures, (c) the practice of green manuring.

(a) *Crop rotation* retards where continuous cropping hastens soil deterioration. The one maintains a higher degree of fertility, serves in a way to regulate labor usage, aids in the combat with weeds, and makes for success; the other lowers fertility, reduces yields below the point of profitable husbandry, is a spendthrift with humus. Short rotations including grass and clover are always to be preferred.

As far back as the records of agriculture run, one finds evidence of the practice of crop rotation. Empirically done at the outset its benefits are now explained. To be sure the validity of the theory which has had vogue for a couple of generations is now attacked, but it still is accorded credence by most students. The older theory lays stress on the balancing of plant food drafts by cropping with divers crops of various needs and unlike habits of growth. The other explains its benefits by intimating that the continued growth of a single crop brings about an unsanitary soil condition through the accumulation of toxic or poisonous excretions, which check its growth while not affecting that of other and unallied crops. The one may be termed the theory of soil exhaustion, the other of plant excretion. It may not be amiss to discuss the benefits of crop rotation as viewed by the advocates of each hypothesis.

It is usually held that crop rotation is of service:

1. Because it tends to equalize the drafts of plant food. Thus grain crops tend to use phosphoric acid excessively; silage

corn and market garden crops, nitrogen; potatoes, potash. To grow grain continuously would tend unduly to lessen the phosphoric acid content, but to interject potatoes and grass into the rotation tends to balance the withdrawals of plant food.

2. Because deep and shallow rooting crops feed from different soil areas, thus gaining access to increased food supplies.

3. Because the humus content of the soil may be maintained or increased instead of lessened as must needs happen when the same crop is continually grown.

4. Because thus the combat against weeds, fungi, and insect pests may be waged more successfully than when grass crops are sown year after year or lands remain in permanent meadow. Intertillage kills weeds; potato scab which abides in the soil from which scabby potatoes have been taken, does not attack the corn or clover crops which follow; and a plowed meadow may be in some measure rid of grass infesting insects.

The exponents of the excretory theory accord weight to these arguments, but allege an additional reason for the ill-success of continual cropping, viz.: that certain unknown organic substances exude from plant roots, which, on accumulation, become harmful to the further growth of the kind of plants producing them. These toxic bodies are held to be less injurious to plants of another sort, and hence rotative cropping succeeds where continuous cropping fails, the accumulations being disposed of before the same crop again appears in the rotation. They intimate that the abilities of soils rich in humus to withstand the effects of continuous cropping are due to the powers of that humus to dispose of these excreted products. They further affirm that manurial benefits are due less to soil enrichment than to soil renovation, regeneration, purification, to the effect of the added humus, either destroying or so modifying these poisonous substances as to render them harmless; they hold that commercial fertilizers exert a similar action, being antidotes as well as foods; and they ascribe the benefits of thorough tillage and intertillage in part to the effect of the aeration thus produced on these toxic bodies. In support of this hypothesis are pointed out the large residues of nitrogen, phosphoric acid, potash and lime in long cropped "exhausted soils"; certain results attained with water culture and special pot cultures; and data secured wherein the use of certain purifying agents, notably carbon black, have been followed by satisfactory growth.

However, whether the malady is due to exhaustion or to excretion, to starvation or to poisoning, whether the soil is of poor texture or is "unsanitary," whatever the cause of soil unthriftiness, there is no dispute as to the remedial measures. Doctors may disagree as to what causes the disease, but agree as to the medicine. Crop rotation! the use of barnyard and green manuring! Humus maintenance! These are the fundamental needs.

It is outside the province of this article to deal specifically with advice as to rotations. There are a multitude of good ones and many good farmers follow no system in this regard. The salient points to be observed in this matter are to make use of three classes of crops, one which will sell well, one which has fertilizing value, and one which will tend to free the soil of weeds, i. e. money, manurial and cleansing crops, as for example potatoes, grass and clover, and corn.

(b) *The use of farm manures* was discussed with some thoroughness in bulletin 108 (1904), their chemical composition and physical characteristics, their wastes, application and use. And last year in bulletin 130, their fermentation and relation to bacterial life of the soil was reviewed. In neither bulletin was stress laid upon the particular point now in hand, the maintenance of an adequate soil humus content. The many sidedness of this common farm product is none too well apprehended, and this is one of its prominent facets. Rich in organic vegetable matter already partly decomposed, in condition for and containing agents inducing further and rapid decay, it is ideal and rich humus of the best sort. To learn that "manure is considered a farm nuisance"; that "in Oregon a neighbor is welcome to haul (it) away"; or that it "is burned"; that in California it "is dumped into ravines"; that in Oklahoma "it goes to the creek"; in Kansas "hauled to a hole in the ground or put on one side of the field"; in South Dakota burned "to be rid of it" or "for fuel"; in North Dakota piled and left "until it disappears"; in Missouri "deposited by the roadside"; in Idaho "often piled as high as a barn"; that in many sections farmers "have a grievance against it, claiming * * * * that it produces dog fennel (or) other weeds and * * * * * that it poisons the soil (so) farmers are afraid of it"[1]; all this sounds amazing to eastern ears. The writer, during a Californian visit, was assured by a native farmer that having heard that cow manure would promote crop growth, and being skeptical of the truth of such a statement, he had tried it; and with the utmost naivete he said: "And do you know it really did make the crop better." The West needs to learn to use manure; the East to use it better. No one gets its maximum value; many get but half. The significant statement is made by the head of the Farm Management office of the United States Department of Agriculture, who in person or by deputy meets thousands of farmers yearly, that he "has seen few farmers who had no apologies to make for their methods of handling manure."

The farmer who has access to a good peat or muck deposit can thus build up the humus content of his soil. Gathered during the summer, weathered over winter to oxidize ferrous salts and to dry it out, used as an absorbent in the stables, other than the cow stables, mixed with land plaster to lessen acidity, or composted with manure, it makes an admirable humus former, well adapted to use on light soils. There are peats and mucks, however, some of high grade, others of low grade. Analysis may well precede usage. The Station has under way a very complete survey of the peat deposits of the State which it hopes to publish within a year.

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[1] Holmes, Practices in Crop Rotations, U. S. Dept. Agr., Year-book (1902), page 529.

GREEN MANURING

A crop grown specifically for the purpose of soil improvement, to be plowed under and rotted, constitutes green manure. The practice antedates Christianity. Much has been claimed for it, sometimes too much. Its direct service in regions where animal husbandry obtains is less than in those where manure supplies are scanty; yet it often is worth while, particularly in regions where mild winters prevail, to keep the ground clad during the fall, winter and early spring in order to lessen nitrogen losses, to diminish erosion, and to augment the humus content of the soil. Green manuring on barren sands, on worn-down soils, or in lieu of fallowing, has its place; but thus to handle good soils in regions where dairy husbandry is the vogue is irrational and wasteful, since equally good results may be attained by the harvest and feeding of the crop. In other words it is uneconomical to plow under for plant food a crop which may be used both for plant and for animal food. However, the system has much vogue in other sections, particularly in the South, and should have some in Vermont; and a survey of the causes and remedies of soil deterioration were incomplete without its consideration.

The benefits which may be derived from green manuring are of two sorts, chemical and physical; that is to say, the plant food content of the soil may be affected as well as its texture.

CHEMICAL

1. The *availability of the mineral forms of plant food* is augmented through the growth and decay of crops. If the crop roots deeply plant food, particularly potash and phosphoric acid, is translocated from subsoil to surface soil. The deeper roots constitute but a small fraction of the entire mass, yet they afford upward passage to considerable amounts of deep lying mineral matter.

2. The *soil nitrogen supply* may be both conserved and increased by green manuring; conserved by the capture of fugitive nitrates, increased by the capture of aerial nitrogen through the

growth of legumes. These matters are fully discussed in the 1907 bulletin (130, pages 244-260, 266-267).

3. The *humus* store of the soil is greatly augmented. Indeed this is often the most important object. (In this connection see pages 155-158.

PHYSICAL

4. *Soil texture* may be improved by green manuring. The deep rooting crops tend both to modify and to mollify the soil, opening it up to air and moisture. The buried and rotting herbage tends to make lighter soils, more retentive of moisture and darker in color, and to render those of a clayey type more porous, mellow, friable and workable, less likely to puddle or to bake, and less prone to erosion.

5. *Erosion* is the bane of southern agriculture and in many countries has made waste once fertile fields. Surface washing, which gullies hillsides and, carrying the finer soil particles to lower levels, occurs on a large scale but rarely in New England. Wind erosion is also not uncommon. Both may be lessened by soil occupation by a crop. (See pages 148-150).

6. *Weed killing* is promoted by the complete occupation and shading of the soil afforded by a green manure crop.

The practice is not one of universal application. On a soil already well stocked with humus; or where clover works well in a rotation; or where manurial supplies are ample; or in arid or semi-arid regions where decay is retarded; under such conditions green manuring is not applicable. But as a builder up of poor soil, particularly of a sandy type; as a means of restoring humus; as a means of lessening erosion, it is a serviceable procedure. Many crops are used as green manures. They readily divide into two classes, those which do and those which do not gather nitrogen, the legumes and the non-legumes, the nitrogen purveyors and the nitrogen consumers. The desiderata are a rapid, vigorous growth, a deep, widespreading root system, thus providing humus and against soil washing, and extreme hardiness that growth may continue until frost, thus holding nitrates as against the losses caused by autumnal rains. If in addition the crop is a legume, and many such are as effective for this purpose as is any non-legume, so much the better.[1]

Preeminent among the green manuring crops[2] of a non-legume type are winter rye, buckwheat and rape; among the legumes, the sundry clovers, peas, beans and vetches. "There are others"; but these include the more prominent choices. Concerning them it may be said:

Rye.—Most commonly used as a fall and winter cover. May be seeded late after harvest, grows quickly, withstands severe winters, is an avid feeder, makes early and rapid spring growth, enabling it to be plowed under early. An admirable cover and humus maker; may be sown at any time from August to October (two to three bushels per acre), often at the last corn cultivation or after potato harvest as a catch crop. Especially suited to light soils.

Buckwheat.—Serviceable as a soil improver, particularly when new lands are broken up; makes relatively heavy and rapid growth on medium to poor soil; a summer sown crop (one bushel per acre), shallow rooter, not hardy, not serviceable as a nitrogen conserver. Especially used to better the character of the soil by keeping it covered in mid-summer and by adding humus; grows readily on inferior soils.

Rape (Dwarf Essex).—Sown after the harvest of an early crop, grows late in fall and up to frost. It may serve both as cover crop and pasturage. Forms a fair winter mulch against washing and leaching.

These crops are essentially catch crops. Even though pastured or harvested, the soil is the better for their growth, since an occupied soil is preferred to one which is unclad.

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[1] In this connection see bulletin 130, pp. 244-260.

[2] Catch crop and cover crop are terms commonly used as synonyms for green manuring crop. The one refers more particularly to what might be termed the intermediateness of the location of the crop, sandwiched in as it were in the rotation between other crops; the other, to its use as a blanket as against washing, to maintain warmth, etc.

Clovers.—The varieties commonly grown are red, mammoth red, alsike, and crimson.[1]

Red.—Adapted to a wide range of soil and climate. Liable to winter killing on heavy soils (root tearing from alternate freezing and thawing) and to summer burning on light soils. Sown about August 1 (in corn at last cultivation) 12-16 pounds per acre, it becomes well established before snow falls and is less likely to winter kill. As green manure, the first crop hayed, the second plowed under; or as a hay or silage crop directly for two or more years; or sown with grass seed, usually timothy for two or more years, for the forcing of a denser sod; or as a crop by itself in a short rotation, it has few rivals. Its stubble alone vastly improves the soil for a series of years and betters the yields of the succeeding crops. It is best used for food purposes and the manure returned to the soil. Deep rooted, hardy, a nitrogen gatherer and conserver, a winter soil protector, a humus maker, a rich roughage ration former. It is most appropriate that the red clover has been made the State flower wherewith to feed the cow on the State seal.

Mammoth red.—A coarser plant, a wider forager than the red. Better adapted to moist soils; on the whole to be preferred for green manuring purposes.

Alsike.—Better fitted to damp soils than red clover, hardier, withstands the winter better. Smaller, more creeping in habit. If sown eight to ten pounds per acre, preferably with red or mammoth red clover, 1 to 4 parts by weight, equal amounts of each variety are secured. Less advantageous as a green manure than red or mammoth.

Peas.—The Canada field and the cow peas are commonly used. The latter, which strictly speaking is not a pea but a bean, does not seem adapted to climatic conditions in northern New England. It is the best green manuring crop used in the South and is much grown from New Jersey southwards. Certain early ripening varieties may possibly serve here, but they are usually rated as inferior to crops which mature. The field pea, however, is perfectly at home and thrives well in cool moist seasons and on good soils. It does not do as well on poorer soils and hence is not perfectly adapted to the green manuring purpose. It is rarely thus used, however, in regions where dairying obtains. From 1.5 bushels to 2 bushels, sown 2-4 inches deep, are advised.

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[1] The latter, an annual, is rarely grown in New England, and indeed seems to possess no advantages over red clover for this region. In sections where it readily thrives—New Jersey, Delaware, Pennsylvania and westward—it has a place, but not here.

Beans.—The soy and velvet beans are used as green manures. The latter is grown only in the far South. The former, an erect, broad-leaved, bushy plant, makes a better green manuring crop in New England than does the cow pea, thriving well. Sown broadcast, 1 to 1½ bushels per acre, in a warm and well fitted seed bed, it grows vigorously, furnishes much organic matter which decays rapidly when buried. It is well relished by stock as a soiling crop or mixed with corn as silage.

Vetches are slender twining plants, annuals, hard to harvest, an admirable orchard cover crop. They are ill-adapted to dry soils or seasons. The seed is rather costly, a bushel per acre being needed.

Lupines are annual, deep rooted plants largely used in Europe as green manures, but seldom seen here. *Sweet clover* (*Melilotus*), a not uncommon weed plant in the Champlain valley, serves the purpose well and is also a fine bee plant, though useless for forage for cattle.

The *practice* of green manuring has its limitations and its dangers. It may accomplish one or more of the several good things cited on pages 169-170 ; and it may do harm. Conditions govern. One should have a clear idea of the aim sought, be it humus production, the prevention of nitrogen escape, the gathering of nitrogen from the air, the control of erosion or what not, and vary crop and plan accordingly. Thus if humus is the great desideratum, buckwheat and rye may be chosen; if nitrate losses are feared, a fall growing crop like rape serves the purpose; if soils lack nitrogen, legumes are grown; if wind or water sweep soil away, soil binding crops, with fine fibrous roots are chosen. An open and porous soil, naturally poor in nitrogen, from which a crop has been taken, is not likely to need protection against nitrate loss; neither is one with a close, retentive subsoil. One already well stocked with nitrogen is but slightly benefited by legume growth, since the legumes draw on soil nitrogen, if present in ample supplies, more readily than upon atmospheric supplies. Nitrogen gathering from the air ensues most certainly when soils are well drained, are not acid, are well supplied with available mineral elements, are insufficiently stocked with available nitrogen, and when the nodule producing organisms are present (see bulletin 130, pages 247-260). A clear understanding of these facts will go far towards determining success or failure.

The green manuring practice will not alone suffice to renovate a run-down soil. If a non-legume is grown, not one jot nor one tittle of plant food is added to the soil store thereof. Humus, air derived organic matter, is gained and that is all. If a legume is used, nitrogen also is secured; but its gathering in quantities sufficient to make the procedure economically worth while, is conditioned largely on the presence of reasonable amounts of available potash, phosphoric acid and lime and on at least a fair physical condition of the soil. In other words, ill-fed plants gather no nitrogen. Given a wretchedly poor soil, deficient in all forms of available plant food, improvement through legume usage can only be attained by otherwise supplying the needed minerals. On heavier soils, however, such as the clay loams, commonly well stocked with mineral plant food though relatively unavailable, legumes may add all the four deficients to the surface soil, nitrogen from the air, phosphoric acid, potash and lime from the sub-soil, translocating thus within the reach of more shallow rooting plants and rendering available, plant food otherwise out of reach and insoluble. This is a prime reason why clover is so admirable a renovator; why its interjection into a rotation serves to maintain fertility and to increase crop growth. This, too, whether it is plowed under entire, or the tops fed and stubble plowed under; for the roots and stubble carry about a third of the humus and nitrogen contents of the entire plant. If, then, the manure is returned to the soil, 90 percent of the total manurial value may be secured.

Quite as important as the growth of the crop is its destruction. It must be turned under aright, lest one do serious damage to both soil and succeeding crops. Light soils may be harmed if a heavy growth is turned under in warm and moist weather, in that it is liable to ferment too rapidly, and cause over-acidity. Or, again, if the soil or weather is over dry, the mass may lie indefinitely undecayed, cutting off the connection between soil and sub-soil, hindering the rise of capillary water and leading to surface drying. These dangers are less to be feared on heavy than on light soils. Again, some green manuring crops, turned under a bit too late in the spring, having got somewhat mature and made heavy drafts on the soil contents of moisture and of available plant food, leave too little food and drink for the succeeding crop, which suffers accordingly, germinating slowly and growing at first but feebly.

It is often desirable under these conditions, particularly if the crop is a very heavy one, to add lime in order to hasten decomposition and to neutralize acidity; and perhaps to roll the soil after it is otherwise fitted, the more closely to pack down the green mass. Sometimes a partial removal of heavy tops is advised. A drag chain aids in the more complete burying of the herbage. Hence, generally speaking, crops to be turned under in the spring should be thus treated at the earliest possible moment, particularly if the regular crop is of primary importance and the catch one secondary. Ordinarily a two weeks' interval between plowing under the reseeding is none too long. Fall green manuring crops may sometimes be left till spring, even though winter-killed. Their manurial and humus making values are not seriously lessened and, in latitudes where snow-clad fields are less common than in Vermont, they serve to lessen surface wash, as, indeed, they may do here in the spring time on steep slopes.

SUMMARY

Why are the soils which were once productive now relatively impoverished? The common belief is that their fertility (plant food content) is exhausted. Both the supposition and the usual conception of the meaning of the term fertility are incorrect. The main causes of soil deterioration are:

1. Surface washing or wind blowing; erosion.—Pages 148-150.
2. Nitrogen losses from unclad soils.—Page 150.
3. Faulty moisture conditions.—Page 150.
4. Faulty soil texture.—Page 150.
5. Unsatisfactory soil bacterial conditions.—Pages 150-151.
6. Shortage of available plant food.—Pages 151-152.
7. Soil acidity.—Page 152.
8. Depletion of the humus supply.—Page 153.

Numbers two and five were discussed in bulletin 130; numbers three and four in bulletin 123; number seven in bulletins 99 and 130. The others, particularly the last, are discussed in this issue.

1. Erosion is due to surface washing with water or to wind sweeping; is more common in the South and far West than in New England; is a serious menace to national welfare; is due to climatic conditions and to ill-advised methods which lessen humus supplies; and is to some extent controllable by forest preservation, forest plantings, grass culture, level culture, terracing, side-hill ditching, etc.; by deep plowing, the use of manure, green manuring, and crop rotation.—Pages 148-150.

6. The shortage of available plant food is rarely due to inherent soil poverty, but usually to misuse. Experimental home trials to determine fertilizer needs, adequate tillage, manuring or green manuring are to be advised.—Pages 151-152.

8. The depletion of the soil humus supply is apt to be a fundamental cause of lowered crop yields. The one crop system, fallowing, shortage of manure, no green manuring; the non-use of legumes or grasses in the rotation; deforestation, fires,

the continued use of commercial fertilizers; all these tend unduly to lower the humus content. This complex organic soil ingredient supplies nitrogen and available mineral plant food, augments the water storage capacity, promotes its warmth, betters its texture and permeability, and aids micro-organic growth. Seriously to lessen its content in the soil is to lower the crop producing power of the individual farm and to impair national resources. Its lack may be diagnosed by careful observation, but it is particularly apt to be deficient in the more open and porous soils. The supply is best augmented by adequate crop rotation, using legumes and grass as renovating crops, by the free use of farm manures or by the practice of green manuring.—Pages 153-175.

Articles dealing with the matter discussed under the heading "Soil Deterioration and Soil Humus":

Snyder.—Humus in its relation to soil fertility, United States Department of Agriculture Year-book for 1895, pp. 131-142 (1896).

Hilgard.—Soils, Chap. viii (1906).

Fletcher.—Soils, How to Handle and Improve Them, Chaps. xi, xii (1905).

Snyder.—Soils and Fertilizers, Chaps. iii, xii (1905).

Holmes.—Practices in Crop Rotation, United States Department of Agriculture Year-book for 1902, pp. 519-532 (1905).

Voorhees.—The Natural Improvement of Soils, Pennsylvania State Department of Agriculture, Bulletin No. 102 (1902).

King.—Tillage; Its Philosophy and Practice. Article in Cyclopedia of American Agriculture (Bailey), Vol. i, Chapter xi, pp. 378-387.

Snyder.—Some of the Chemical Properties of Soils. Article in Cyclopedia of American Agriculture (Bailey), Vol. i, Chap. x, pp. 357-362.

Whitney.—Exhaustion and Abandonment of Soils. Testimony before Industrial Commission, United States Department of Agriculture Report No. 70 (1901).

Brooks.—Catch Crops, Massachusetts State Board of Agriculture Report 46, pp. 316-338 (1898).

Spillman.—Renovation of Worn Out Soils, United States Department of Agriculture Farmers' Bulletin 245 (1906).

Penny.—Cover Crops for Green Manure, Delaware Station Bulletin 60 (1903).

Whitney.—United States Department of Agriculture Farmers' Bulletin 257 (1906).

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BURLINGTON, VT.

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JUNE, 1908

Abstract Twentieth Report, 1906-07

(Plant Disease, Horticulture, Weeds, Insects)

PLANT DISEASES.—Pages 188-206.
WEEDS.—Pages 206-210.
HORTICULTURE.—Pages 210-219.
DRUG PLANTS.—Pages 219-220.
INSECTS AND INSECTICIDES.—Pages 220-222.
INDEX.—Pages 223-224.

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Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

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BULLETIN 136.—ABSTRACT TWENTIETH ANNUAL REPORT, 1906-7
PLANT DISEASES, WEEDS, HORTICULTURE, INSECTS

JOSEPH L. HILLS

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INTRODUCTION

Following the precedent established four years ago, abstracts of the twentieth annual report are presented in this bulletin and the succeeding number in which the matters of more direct practical interest are briefed. Recipients of either bulletin desiring to receive the full report have but to ask, specifying by its number—twenty.

The twentieth report marked the close of as many years of station existence. Since preceding issues are mostly out of print, but frequently called for, it seemed both desirable and appropriate to gather therein brief resumés of such studies as possessed more than ephemeral interest. In the two abstracts presented are statements:

No. 136—Concerning plant diseases, weeds, horticulture, insects and insecticides.

No. 137—Concerning crops, stock feeding, and dairy husbandry.

The writer is responsible for the editing of the briefed matter. The articles to which authors' names are attached are condensed from the new matter appearing in the twentieth report. The material as printed in the report which is condensed from previous publications shows authors' names and gives references to the original publications. Owing to exigencies of space only the barest outlines are given.

THE OCCURRENCE OF PLANT DISEASES IN 1907

N. J. GIDDINGS

The wet, cloudy weather of the spring and early summer favored the development of many plant diseases. Other maladies, however, received a severe set-back in late July and August, when hot, dry weather ensued. The rainy weather of September revived some dormant parasites, but they did not cause much damage.

POTATO DISEASES

Insect injuries.—The Colorado beetle and flea beetle were very destructive where not properly held in check. The former is easily controlled by paris green, but the latter is not thus appreciably affected. The bordeaux-paris green combination, however, was very effective in combatting both beetles.

A large number of seedling plants were destroyed by wire worms, the entire base of the stalk being perforated.

The amount of tip-burn was unusually large. It usually results from a long, hot, dry spell. Working in conjunction with the early blight and flea beetle it caused considerable loss during the drouth of last midsummer. Plots sprayed with bordeaux mixture showed much less of this trouble than did other plots.

Early blight.—This disease was quite destructive. The dry weather of midsummer favored its development, especially on sandy soils. On many fields one-sixth of the total active leaf surface was thus destroyed. Since diminution of the living leaf surface proportionately reduces the tuber yield, the early blight caused much loss in 1907. Spraying with bordeaux mixture proved a quite effective check to this trouble. There were only one-third to one-half as many badly diseased leaves this year on the bordeaux plots as on the check plots.

Leaf blotch.—This disease was described in detail in the 19th report. It was found again in 1907, a severe outbreak occurring near the Experiment farm on a field where a few diseased leaves were noted in 1906. Potatoes were again planted in this field in 1907 and a great many leaves were practically covered with the leaf blotch fungus, as were likewise the leaves of a weed found growing in a thicket remote from tilled land, an occurrence which raises the question as to whether the fungus, hitherto assumed to be introduced from Europe, may not be native.

Late blight.—The late blight fungus did but little damage in this immediate vicinity. The September rains, however, favored its development and a considerable loss occurred in central Vermont nearer the mountains, and in other states the disease caused great loss. Favorable weather conditions next year will insure its destructive development where potatoes are not properly sprayed. Bordeaux mixture is the best known preventive preparation.

Scab was prevalent in many fields. Planting in new soil and disinfecting tubers with formalin just previous to planting are found effective methods of control.

Black leg.—Several tubers taken from diseased hills in 1906 were planted on a sandy loam in 1907. They made normal growth, but showed no disease. Some Beauty of Hebrons immediately adjoining these, however, showed several hills affected with "black leg." The latter seed was bought of a local dealer. Two other varieties in the same field showed no traces of the malady. Reports were received of black leg from Maine and Massachusetts. Specimens secured from Maine resembled in appearance those collected here. A Massachusetts correspondent states that the disease occurs with him most frequently with new seed, and that he rarely finds any the second year after such introduction. It is not easy to reconcile these conflicting observations. The writer inclines to the belief that it is apt to be carried on or in the tubers, but that soil conditions determine its destructive development.

ORCHARD DISEASES

Apple canker is still prevalent and is easily controlled by pruning and spraying.

Black knot of plum was more destructive than usual, the fungus being favored by the long continued spring rains. The disease is easily held in check by proper pruning and spraying.

Brown rot of the plum caused considerable loss among susceptible varieties. Wherever the plums hang in clusters touching one another, rot development is favored. The spores are washed down in rains and any which chance to lodge between two plums that touch are apt to be held there, and to find conditions favorable to growth. If one plum of a cluster is seen to be diseased it should be destroyed at once, as others in the cluster are almost sure to go if the rotting one hangs long in contact with them.

GARDEN DISEASES

Club root.—This disease was widespread, as usual. It troubles market gardeners in various portions of the State, and must continue to increase until greater care is taken to prevent dissemination. Cabbage plants should be started in soil which has not been previously used for cabbage culture. A field in which the disease is found should be kept free of cabbage, turnip, and kale, and other weeds of the mustard family for several years, since the fungus lives over in the soil and thrives on any plants of this family.

Muskmelon anthracnose.—This disease did considerable damage in market gardens, the September rains favoring its spread. This trouble is present more or less every year, but the loss is generally small. Spraying with bordeaux mixture about July, and every two weeks thereafter until late August, is effective in its control.

A *muskmelon rot* of a bacterial nature attacked experimental melons, but does not appear to have been widespread.

FOREST DISEASES

Pine blight, an obscure disease of the white pine, has been prevalent for several years past. Its cause is as yet undetermined, but is being investigated by the Bureau of Plant Industry of the United States Department of Agriculture.

POTATO SPRAYING EXPERIMENTS

L. R. JONES AND N. J. GIDDINGS

Experimental trials of fungicides upon potatoes have been carried on for 17 years. Those of 1907 were designed to show:

I. The gain from spraying with bordeaux-paris green and the comparative results from 2, 3 and 4 applications.

II. The gains from commercial compounds (Boxal and Bug Death) as compared with bordeaux mixture and paris green.

THE GENERAL PLAN OF THE EXPERIMENTS

These experiments were conducted on a level sandy loam fairly uniform in its character. The trials were planned primarily to test fungicidal values; but certain insects and fungi come at about the same season and it is often impracticable to tell the gains due to fungicidal effects from those due to insecticidal or other action. All held the Colorado beetle in check. Flea beetles were present as usual and did considerable damage where not controlled. Much of the difference in results is due to the greater or less control of these pests.

The early blight fungus occurred destructively and distinct evidence was obtained as to the fungicidal value of the various compounds as against this malady. The late blight fungus was not found, and none of the gains can be attributed to its control; and there was no rot whatever in the tubers.

THE GAIN FROM THE USE OF BORDEAUX MIXTURE

Trials have been made since 1891 to determine this matter. Bordeaux has shown beneficial effects as a fungicide, an insecticide and as a tonic. These factors vary from year to year, therefore the results vary; but in every trial spraying has proved distinctly beneficial. The bordeaux used was made of 5 pounds copper sulphate, 5 pounds lime and 50 gallons water, and mixed fresh. To this was added one-half pound paris green for all applications, except the last (August 22). 150 gallons per acre were used twice and 200 gallons, twice. The control rows were poisoned at the same dates with paris green alone, mixed with slaked lime, one pound poison to 20 pounds lime, 30 pounds per acre being applied. Green Mountain potatoes, planted May 25, were used.

Plot 1. Bordeaux applied four times, July 16 and 25, August 8 and 22.
Plot 2. Bordeaux three times, July 25, August 8 and 22.
Plot 3. Bordeaux two times, August 8 and 22.
Plot 4. Control, paris green in lime.
Plot 5. Bordeaux four times, July 16, 25, August 8, 22.
Plot 6. Control, paris green in lime.
Plot 7. Bordeaux three times, July 25, August 8, 22.

Paris green was applied at the earlier dates on plots 2, 3 and 7, to check the Colorado beetle. The beneficial effects of bordeaux were seen in early August and were increasingly evident later on. This was the more noteworthy since there was no trace of late blight; the benefits being due to the control of early blight and insect troubles, save in so far as the less definite physiological effects were of help. The latter were operative, however, as shown by the relatively richer green of the sprayed foliage and the lessened amount of tip-burn.

In order to get definite data as to the relation of spraying to flea beetle and early blight injuries, critical examinations were made September 6. Typical plants were selected in each plot and counts made of those leaflets badly blighted and of those severely punctured by flea beetles. Averages were as follows:

	Leaflets badly eaten by flea beetle	Leaflets badly diseased with early blight
Bordeaux twice, Aug. 8, 22	95%	75%
Bordeaux three times, July 25, Aug. 8, 22	55	45
Bordeaux four times, July 16, 25, Aug. 8, 22	48	40
Paris green in lime	97	80

The results are striking and conclusive. The August 8 and 22 applications were ineffectual to a large degree. The July sprayings were the ones which chiefly prevented these two pests from obtaining their foothold in the field.

The yields per plot are shown herewith:

		Large tubers Pounds	Small tubers Pounds	Total yield Pounds	Gain in market'le tubers over check Pounds	Gain in market'le tubers over check Percent
Plot 1.	Sprayed four times......	218.8	41.6	260.4	138.8	172.5
Plot 2.	Sprayed three times......	158.4	47.6	206.0	78.4	98.
Plot 3.	Sprayed two times	154.3	51.8	206.1	74.3	92.9
Plot 4.	Check paris green........	80.0	56.9	136.9	.....	.....
Plot 5.	Sprayed four times......	165.1	50.4	215.5	79.8	93.5
Plot 6.	Check paris green.......	85.3	59.5	144.8	.....	.....
Plot 7.	Sprayed three times......	130.0	56.3	186.3	44.7	52.4

The gain in plot 1 over 2 was 26%, and in plot 5 over 7, 16%. Under the conditions of 1907 the first spraying (mid-July) was important. Probably three thorough sprayings made about July 15, August 1 and August 15, would have done as well as four. The first application of bordeaux should be made about mid-July. Since most potato sprayers apply only 50 or 75 gallons per acre, one must go over the rows twice to secure as thorough an application as is here recommended and practiced. If this is done a 2 or 3 week interval may elapse between dates of spraying. In actual farm practice, however, it will probably prove better to use the single lighter application and to go over the field more often, i. e., once in a week or ten days. Thus if the first spraying was made the second week in July, four or five such applications would be advisable. If, however, a period of moist, warm weather intervenes and the late blight threatens, it is advisable to make a thorough application, using at least 150 gallons per acre. With ordinary spray carts it might be necessary to go over each row twice, making the second application in the opposite direction from that of the first, so as to cover the foliage more effectually.

The results are entirely in harmony with those of preceding years. Some years the gain is large, in others it is smaller; but in any case it pays to spray and so to insure a full crop.

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per acre		Gain per acre
		Sprayed	Not sprayed	
White Star,				
May —, 1891	**Aug. 26, Sept. 8,**	**313 bu.**	**248 bu.**	**65 bu. or 26 %**
May 20, 1892	**July 30, Aug. 13, 25,**	**291 "**	**99 "**	**192 " " 194 "**
May 20, 1893	**Aug. 1, 16, 29,**	**338 "**	**114 "**	**224 " " 196 "**
Apr. 26, 1894	**June 16, July 17, Aug. 30,**	**323 "**	**251 "**	**72 " " 29 "**
May 20, 1895	**July 25, Aug. 13, 31,**	**380 "**	**219 "**	**170 " " 78 "**
Polaris,				
May 15, 1896	**Aug. 7, 21,**	**325 "**	**257 "**	**68 " " 26 "**
June 1, 1897	**July 27, Aug. 17, 28,**	**151 "**	**80 "**	**71 " " 89 "**
White Star,				
May 10, 1898	**July 21, Aug. 10,**	**238 "**	**112 "**	**126 " " 112 "**
Average,				
3 varieties,				
May 18, 1899	**July 26, Aug. 17, Sept. 8,**	**229 "**	**161 "**	**68 " " 42 "**
Delaware,				
May 23, 1900	**Aug. 4, 23,**	**285 "**	**225 "**	**60 " " 27 "**
May 25, 1901	**July 20, Aug. 21,**	**170 "**	**54 "**	**116 " " 215 "**
May 15, 1902	**Aug. 1, 20,**	**298 "**	**164 "**	**134 " " 82 "**
Green Mountain,				
May 1, 1903	**Aug. 10,**	**361 "**	**237 "**	**124 " " 52 "**
Delaware,				
May 25, 1904	**Aug. 1, Sept. 1,**	**327 "**	**193 "**	**134 " " 69 "**
May 15, 1905	**Aug. 2, 21,**	**382 "**	**221 "**	**161 " " 73 "**
Green Mountain,				
May 27, 1906	**Aug. 13, 22,**	**133 "**	**101 "**	**32 " " 32 "**
May 1, 1907	**July 16, 25, Aug. 8, 22,**	**171 "**	**63 "**	**108 " " 175 "**
Average of	**17 years,**	**278 "**	**165 "**	**113 " " 68 "**

A COMPARATIVE TRIAL OF BOXAL, BUG DEATH AND BORDEAUX-ARSENICAL MIXTURE

Numerous inquiries have come as to the value for use on potatoes of the commercial preparations known as Boxal and Bug Death. Trial plots of 10 rows each were therefore laid off for treatment as follows: Two rows Bug Death, two rows Boxal, two rows bordeaux mixture, four rows paris green. The bordeaux was of the 5-5-50 formula and one-half pound paris green was added to 50 gallons. The first three applications were 150 gallons per acre and the last two, 200 gallons. The control plot received paris green in lime, 1 to 20, at the rate of 30 pounds per acre. The Bug Death and Boxal were mixed with water at the rate of one pound to 10 gallons. It seems necessary to apply Bug Death liberally to keep the plants free from Colorado beetles, and 25 pounds to the acre of Bug Death and 19 pounds to the acre of Boxal were used. The primary aim was to test the relative efficacy of these compounds against the other insects, chiefly flea beetles, and as fungicides and general tonics. Hence liberal applications were continued through the summer, regardless of the special need so far as concerned the simple control of the Colorado beetle. All the preparations were applied five times at the following dates: July 9, 15, 26, August 8, 22. A marked beneficial effect was apparent during late August and September on all the plots treated with the spray compounds over the check plots. This effect, however, was much more apparent on the bordeaux plots than on any of the others. On September 6 leaflet counts were made to determine approximately the relative damage by flea beetle and early blight, with results as follows:

Treatment	Leaflets badly punctured by flea beetle	Leaflets badly diseased by early blight
Bug death	52 percent	47 percent
Boxal	60 "	60 "
Bordeaux	37 "	32 "
Paris green and lime	95 "	88 "

The Boxal and Bug Death are quite effective in checking the flea beetle and early blight, the early blight to a somewhat less degree than the flea beetle. Bordeaux was much more effective than either for controlling both the flea beetle and early blight.

On September 30 a count was made of those plants which still had living leaves, and so gave promise of further tuber formation, with results as follows:

Bug death	17 percent of plants alive
Boxal	4 " " " "
Bordeaux	68 " " " "
Check (paris green)	0 " " " "

These figures show a considerable range of difference, but the important point is that the plants sprayed with bordeaux carried much more living leaves than those treated otherwise. At the time of digging (Oct. 11) the plants were all dead in every plot except those treated with bordeaux. The following table gives the yields:

AVERAGE YIELD OF TUBERS OF MARKETABLE SIZE

	Yield of large tubers	Gain over check	Loss when compared with bordeaux
Boxal,	144.1 lbs.	50.5 lbs.=54 %	22.4 lbs.=13.5%
Bug death	127.0 lbs.	33.4 lbs.=35.6%	39.5 lbs.=23.7%
Bordeaux-arsenic	166.5 lbs.	72.9 lbs.=77.9%	....
Check (paris green)	93.6 lbs.	....	72.9 lbs=43.8%

Bug Death and Boxal are preferable to lime and paris green, but neither is as good as freshly prepared bordeaux-arsenical mixture. Both have insecticidal and fungicidal value, but are more costly and less effective than bordeaux.

POTATO DISEASES AND THEIR REMEDIES

Sundry forms of potato foliage disease commonly confounded under the general term "Blight." It used to be held that potatoes suffered from but a single malady, a "blight" or "rot." At least four distinct causes of the premature dying or blighting of the potato leaves are now recognized other than the weakening caused by potato or flea beetle attacks, viz.: late blight, early blight, arsenical poisoning and tip burn. These different maladies are distinctive and may be recognized as follows:

Late blight. A sequel of moist, warm, muggy (usually August) weather. Usually spreads quickly; leaves become black and drooping with offensive and characteristic odor; or may appear as purplish or brownish black spots; fungus is seen as a delicate white mildew on the under side of the leaf.

Early blight. Usually occurs soon after blossoming period; spots irregularly distributed over the leaf, at first small; as spots enlarge, tips and margin tend to roll up. Slower as a rule than late blight, and possessing no such characteristic odor.

Arsenical poisoning. Spots occur shortly after paris green application; traces of poison may be seen in the center of the spots; plants put out new unspotted leaves; spots apt to originate at flea beetle punctures and to show distinct target board like, concentric rings; color a metallic black to brown; no mildew on the spots.

Tip burn. The death of the leaflet at the margin and tip which dry, blacken, roll up and break off.

CAUSES AND PREVENTION. *Late blight.* A fungus (*Phytophthora infestans*). Clean seed; spraying with bordeaux, beginning before the disease appears.

Early blight. A fungus (*Alternaria solani*). Spraying with bordeaux before the disease appears.

Arsenical poisoning. Due to soluble arsenious acid. Use lime with paris green to neutralize the free acid.

Tip burn. Due to dry hot weather and too little water. Increase general vigor of plant.

Relation of time of planting potatoes to disease. Suggestions as to the relation of date of planting to the likelihood of success. "It requires more expense and painstaking to care for early potatoes than to protect later ones." Planting about May 10-20 is suggested if one seeks the largest crop with the least work in protecting it, since it will thus escape the early blight so that spraying need not begin until about August 1. The date of planting should depend upon whether one is prepared or not to spray and also upon the conditions of weather which are to be expected.

Methods of preparing bordeaux mixture. Different bordeauxs look differently, show different color shadings, and settle out differently on standing. Properly made it has a peculiar deep blue color and its very fine precipitate should settle very slowly. The slaked lime may be kept as "stock" if covered with water. Such stock lime is preferable to poorly kept or partially slaked air lime. Copper sulphate may be kept in "stock solution" to be drawn upon as needed. The best results are most surely obtained if such stock solutions are much diluted before combining. One-half of the total amount of water should be used, in which case two-thirds of it may be added to the lime and one-third to the sulphate; but the latter should not be more concentrated. The details of their combination are important. The more quickly and thoroughly they can be mixed the better the result. Especial care is taken to avoid excess of free copper sulphate in any part of the mixture. Equally good results may be obtained:

1. By pouring the dilute lime milk quickly into the dilute sulphate solution and then stirring thoroughly.
2. By pouring the dilute sulphate solution quickly into the dilute lime milk and then stirring thoroughly.
3. By pouring the dilute sulphate solution slowly into the dilute lime milk and thoroughly stirring while adding.
4. By pouring the two together into a third vessel so that the two streams meet, stirring meanwhile until thoroughly mixed.

In all cases thorough and long continued stirring improves the mixture. The best procedure is No. 4, the next best, No. 3.

A gravity system. A lean-to shed served as a support to a two-tier stage or platform. On the upper platform were disposed the barrels for stock solutions of lime and copper sulphate, and, also, those in which these solutions were to be diluted preparatory to mixing in the third vessel on the platform below. These dilution vessels had faucets which were brought close enough together to allow the liquid flowing from both at the same time to be caught in a spout which emptied into the barrel on the lower level. The two solutions simultaneously flowing form bordeaux mixture during their flow into the spout, the precipitate being extremely fine and passing through the cheesecloth strainer. The reaction takes place in the short spout and on the strainer and is continued by the agitation in the mixing barrel. The stock solutions only need be lifted.

Stock solutions. Much time may be saved if stock solutions are prepared. The formula used is the so-called 1-10 formula, that is, 1 pound of copper sulphate or of lime, as the case may be, to every 10 gallons of water. Hence in making up 50 gallons of bordeaux 5 gallons each of the stock solutions (1 pound per gallon) contained the required amounts of these ingredients. These are diluted to 25 gallons each, after which the faucets are opened and the whole process becomes self-operative even to the filling of the spray tank.

Does bordeaux mixture deteriorate on standing? A comparative trial with fresh and old mixtures; conditions otherwise being identical, showed 260 and 229 bushels potatoes per acre respectively when fresh and when old mixtures were used.

Improperly made bordeaux (concentrated stock solutions used instead of dilute ones) proved inferior, was more difficult to apply, needed more frequent agitation and was less adhesive than was a standard mixture.

Preparation and use of sprays. Spray calendar. A popular statement as to objects of spraying, spraying apparatus, formulas, directions for making insecticides, and a "spray calendar" indicating methods of combatting common fruit and vegetable garden pests.

Cost of spraying with bordeaux. What does it cost in materials and labor to spray an acre? No dogmatic answer can be given. Anywhere from 50 to 300 gallons may be needed; 50 gallons may suffice in mid-July and thrice that amount needed on the same piece in August. A half blighted piece in late August has received but 100 gallons and on the same day 250 gallons put on a luxuriant nearby growth. Weather conditions control. In 1891 and again in 1903 only a single spraying was necessary, in other years three have been needed. Speaking generally, however, three applications on medium potatoes planted in mid-May are needed; using 100 gallons in late July, 150 in mid-August and 150 in late August. At the time the article was written the weak bordeaux was figured to cost for materials about a cent a gallon. The cost of application naturally varies with apparatus, skill and vine growth. Three men, one horse, one barrel pump with convenient water, can spray an acre in two hours. The cost of three sprayings is figured at $7 per acre.

Number of times sprayed. Bordeaux was used July 30 and August 13 on part and July 30, August 13 and 25 on the rest of the piece. The gain from the third spraying was "one-third of the total gain." The thrice sprayed plants outlived those sprayed twice. Weather conditions control.

Two late applications (August 9, September 19) were inferior to three (July 21, August 9, September 9) because flea beetle and drought did very great damage before August 9. Nearly one-half the benefit was thus lost. Yet under the climatic conditions of the preceding year two applications—made say July 21 and August 10—would probably have insured nearly as large gains as three. Spraying should be begun in advance of the flea beetle attack. Whether one or two later applications are given should depend upon various conditions—variety, weather and the occurrence of diseases.

The first application (July 26) was the most important, one-half of the entire gain being attributable to it. The second and third were about equal in importance. Each was profitable, since it added 25 or more bushels an acre to the crop.

The next year a single spraying August 4 was the most effective. Those made before were of little avail; those made after did some little good. In deciding when to begin spraying one should use judgment which is only to be gained by experience. For early potatoes planted April to May 5, to spray July 1 and 15, August 1 and again if needed; for medium potatoes planted May 5-15, to spray July 15, August 1 and 15 and again if needed; for late potatoes planted May 15 or later, to spray August 1, 14, 28 and again if needed.

Gains from the use of bordeaux mixture on late potatoes. Experimental sprayings have been systematically made since 1891 and results stated yearly. Gains have always resulted, ranging from 32 to 224 bushels per acre. The 17-year table occurs on page 193.

Spraying as a remedy for early blight. Three and five applications of bordeaux mixture were made on six varieties in adjoining plots. The sprayed plots carried 331 and 316 bushels per acre, the unsprayed 169 bushels. The foliage on the unsprayed plots was from 15 to 90% killed on August 28. One-half of the gain in yield is attributable to the beneficial effects of the bordeaux in other ways than in checking the early blight, i. e., in deterring insects and promoting general vigor. Fully one-half was due to checking the early blight. The foliage was free from the late blight and there was no rot. It was a complete demonstration of the efficacy of bordeaux as a remedy for early blight when applied thoroughly and in season.

The effect of premature death of potato tops upon yield. The potato crop suffers more than is generally realized from the premature death of the vines due to some one or more of the forms of leaf injury. No tuber growth or increase in size takes place when the vines are dead.

Almost half of the money value of a potato crop is formed after September 1. How is it September 1 with unsprayed potatoes? . Few are alive September 10, nearly all are dead August 20.

Will sun drying the tubers lessen rot? Two rows dug on a bright sunny day were in part thoroughly and long exposed to the sun, while the remainder were promptly gathered. Some gain resulted from exposure. If loss from rot is anticipated, exposure to sun and air before storage tends to its abatement.

Temperature of storage and rot development. Tubers were divided into three lots and stored at 70°, 50° to 55°, and at 40° F. for two months. The percentages of the crop unaffected were 31, 47 and 83. Potatoes were selling at 80-90 cents. The moral is obvious.

Relation of date of digging to development of rot. When potato tops are blighting is it better to dig at once or not? Four separate trials were made of this matter, covering several different varieties, locations, soil conditions, etc. The results during the first three seasons were in entire accord and led to the generalization that when potato tops have been killed by the late blight and there is danger of rot they should not be dug for a week or more after the tops were killed. Longer delay does not harm. With late varieties, where the disease progresses slowly, digging should delay until the third week of September at the earliest, and if practicable until after the tops are killed by the frost. During the last season the crop was grown on a heavy undrained clay loam ill adapted to potato culture, especially in the wet season which was experienced. These lost more when harvest was delayed than when it was prompt. This result led to the formulation of an exception to the rule quoted above. When potatoes are grown on a heavy wet soil in a wet season, they should be dug at once when the tops are blighted.

Disease resistance of potatoes. A study of the resistance of potato vines to blight, of potato tubers to rot, and of the tubers to scab. The following conclusions were drawn as a result of the work done in 1904:

"1. Some varieties are less subject to vine injury than are others.

2. Some show a greater tuber resistance to rot than do others.

3. With some there seems to be a fairly close relation between resistance of vine to disease and of the tuber to rot.

4. Selection has not given visible increase of resistance.

Hybridization and the growing of seedling plants followed by careful selection seem to offer a more logical method of securing disease-resistant varieties than does selection."

Further study in 1905 on two types of soil—using 154 varieties, about a hundred being of European and the remainder of American origin,—showed marked difference in the disease resistance of the several varieties, both as to leaf infection by late blight and to rot. In general, varieties having a strong, woody, moderately branched haulm and medium size rather than thick, more or less crumpled, firm, hairy leaves were found more resistant to disease, especially late blight, than were those possessing rather weak, partially woody, much branched, decumbent haulm with rather large, smooth, soft leaves.

The rot resistance of varieties of Dutch and German origin was superior to that of others, the average figures being: Holland 5.6, Germany 7.7, Scotland 18.5, England 18.1, France 32.2, American 37.6%. "American varieties have not thus far been bred for disease resistance." It was noted that while "disease resistance is important, commercial standards are based on prolificacy, appearance and edibleness, qualities in which the German and Dutch varieties are not pre-eminent, as judged by one year's trials and by American standards." These are not at present recommended to American growers.

Potato scab. Much work has been done on this malady. A popular presentation was made in bulletins 28 and 85—the latter of which may be summarized as follows:

This well-known malady is the result of a fungus infestation, which also causes scab on beets and possibly on the roots of other vegetables. It is probably not a native. Its germs occur in great numbers on scabby potatoes, and may cling to the surface of smooth tubers. Much of the loss from scab is directly due to the use of infected seed. When the fungus is not present in the soil a clean crop is assured if clean seed is used. Soil conditions may be favorable or unfavorable to its development. Certain varieties of potatoes are more liable to scab than others. Prevention or control should aim at the selection of resistant varieties, keeping the soil free from the fungus and disinfecting the seed potatoes. It is cheaper to abandon potato growing upon badly infected soil for a time than otherwise to combat the pest. If the soil is free from the fungus any method of fertilizing is safe, but if infected, alkaline fertilizers are to be avoided. Chemical disinfection of soil is not effective enough to warrant the cost. Seed potatoes are disinfected either by soaking one and a half hours in a solution made by dissolving 1 ounce of corrosive sublimate in 7 gallons of water; or by soaking two hours in a solution made by diluting one-half pint of formalin in 15 gallons of water.

Extensive trials in 1900 led to the statements that:

1. A scabby crop ensued when scabby seed was used on a scab free soil; that

2. A clean crop followed the use of a clean seed on clean soil; that

3. No seed disinfection availed if a badly infected soil were used; that

4. The fungus may persist in the soil for a long period of years, whether cropped with potatoes or not; that

5. While corrosive sublimate and formalin are both effective, the latter is more convenient and non-poisonous to stock; that

6. Formalin should be used but a day or two before planting; that

7. Corrosive sublimate, on the contrary, should be used two months before planting; that

8. Flowers of sulphur as a disinfectant or in the row proved ineffective; that

9. Exposure to sunlight for four weeks before planting greatly reduced the scab and hastened the growth of the tubers; that

10. Sulphurous gas used as a disinfectant gave indeterminate results; that

11. Formaldehyde gas proved superior to either corrosive sublimate or formalin.

APPLE, PLUM, OAT AND VEGETABLE DISEASES

Apple scab studies. The control of apple and pear scab has been studied for many years.

1895. "All the sprayed trees (of the previous year) were easily recognized by the cleaner and brighter color of the bark. The buds started earlier and more vigorously." Trees were sprayed four or five times with results as follows: 99% perfect scab-free fruit; only one scabby pear in six barrels where trees were sprayed five times, and but four in two barrels where the trees were sprayed four times. Practically every pear on unsprayed trees was scabby, 19% worthless for marketing, and 81% inferior to the sprayed fruit. The sprayed pears were valued in New York at $2.25, the best of the unsprayed fruit at $1.75. A barrel from the unsprayed tree was worth $1.42, from the sprayed tree, $2.23.

1897. Bordeaux used on Fameuse apples at Isle La Motte resulted as follows:

Sprayed	Selects.	No. 1.	No. 2	Cider apples
5 times	40%	20%	30%	10%
3 times	0	19	53	28
None	0	0	4	96

These apples were estimated at $1.60, $1.40, $1.00 and $0.15 per bushel, and the figures per tree, $15.44, $7.38 and $2.15 respectively. The need of the first and second applications is clear. It is not so clear that the fourth and fifth applications were profitable, but they probably were. In a dry season three or four applications are sufficient. Spraying meant practically the difference between a very profitable crop and a total failure in 1897. But it meant more than this, however. The fruit buds of 1898 were formed in 1897, and the fruit crop of 1898 is measured by the condition of the foliage in 1897. The enormous development of the scab fungus upon unsprayed trees in 1897 must shorten the crop of 1898; so the spraying of 1897 benefitted that year's crop and also that of years to come. The results of spraying are cumulative from year to year. The tree which is properly protected one year makes a stronger growth and a better crop in the next one.

1898. Further work in the same orchard gave the following data:

Sprayed	No. 1	No. 2	Cider apples	Value of crop
Paris green twice....	0%	40%	60%	$0.48
Copper sulphate once.	21	62	17	1.69
Do. + bordeaux once.	58	30	12	2.57
Do. + bordeaux twice	56	32	12	2.80
Do. + bordeaux thrice	67	22	11	3.56

"One cannot afford to grow apples for market without spraying, the gain depending on varieties, seasons and other conditions. The results are cumulative, so that after an orchard has been thoroughly sprayed for several seasons less spraying is required to hold the scab and other pests in check." An application of copper sulphate solution before leaves open and bordeaux-paris green before blossoms open, with one or two applications of latter after blossoms fall is advised for Fameuse.

Apple rust and cedar apples. The "cedar apples" of the red cedar are a fungus growth, their spores attacking the apple leaves and causing rust. Ammoniacal copper carbonate, sprayed twice (May 17 and 30) on a badly infested tree proved beneficial. The leaves on unsprayed trees had nearly all fallen in August and the apples were few, small and valueless; the sprayed tree, while not healthy looking, kept its leaves and ripened about two barrels of good apples. The next year the red cedars were all cut out of the orchard and for a mile radius round about. The result was magical. In former years many of the apple trees were entirely defoliated by rust in August. This past summer not a rusted leaf was found in the entire orchard. The moral is plain. From the scientific standpoint the result is interesting as indicating that the mycelium of this fungus is not perennial in the apple and that the occurrence of the rust in the apple is dependent upon annual reinfection from the red cedars.

Brown rot of plums. A malady due to a fungus (*Monilia fructigena*) propagated from year to year in the mummied plums which remain over winter. To combat it, rotting fruit should be promptly removed and burned or buried. Plowing helps to turn under the spores. Spraying the limbs and trunks before the buds swell with copper sulphate solution (1 lb. in 16 gallons water) is recommended. Ten to 25% of the plum and cherry crops of 1905 were killed.

Oat smut. The causes and remedies of this malady were discussed annually from 1890 to 1896. The applicability of the Jensen hot water treatment for the disinfection of seed oats (soaking at 128° F. for 15 minutes or 133° F. for 10 minutes) was demonstrated. Increased yield following the soaking of the seed was not a constant occurrence, the yield being in some cases depressed. The relationship between source of seed and its smuttiness was demonstrated, the Vermont grown seed as compared with that originating in the West being relatively free from smut. The following table is illuminating:

1892—47 fields Vermont seed.......	0	to 6.3%	average 1 % smut
20 fields Western seed.......	0.2	to 7.4%	average 3.1% smut
1893—66 fields Vermont seed.......	0	to 2.8%	average 0.6% smut
20 fields Western seed.......	0	to 7. %	average 1.6% smut

Not enough smut appears as a rule in native grown seed to necessitate disinfection; but if Western seed is used it pays, since at least 3 to 4% gain per year for several years is entailed, for smut once killed stays killed, if new infection is not introduced.

A soft rot of carrot and other vegetables. An extended study of the occurrence and character of the disease, its pathogenesis, the morphological and physiological characters of the causal organism (*Bacillus carotovorus*, Jones), and of remedial measures.

The malady—a rapid softening rot—was reported from several points and found due to a hitherto undescribed bacterium. The disorganization of the tissues seems due to an enzym which softens the middle lamellae. Many forms of vegetable life are susceptible when wounded, others are not. No infection occurs unless the epidermis is broken. The decay is similar in all cases, viz.: a rapid tissue softening and a liquid exudate clouded with bacteria. The bacillus, single in old, and in chains in younger cultures, with flagelae, motile, non-sporulating (so far as observed) was grown on the usual and on certain special media, and exhibited cultural characters which were recorded, as were also its bio-chemical relations.

Remedial measures recommended were: crop rotation, non-use of manures, the desiccation of root surfaces, their exposure to sunlight, and a low temperature storage room.

Club root and black rot of cabbage and turnip. These destructive diseases of the cabbage, turnip and allied plants threaten to become widespread in Vermont, yet are easily suppressed if taken in season.

Club root, a curious malformation which ruins the plants by preventing the absorption of water and food, was introduced from Europe and is spreading. It has been observed in Vermont but recently. The clubbing of roots is due to their invasion by a parasite which stimulates them to abnormal growth. Once established in the soil, it is very difficult to exterminate. It is perpetuated over winter by spores which form in vast numbers in the clubbed roots. They pass uninjured into the manure of stock fed upon clubbed roots. Such infected manure serves to introduce the germs into the soil, as does also the transplantation of roots from infested soil, where it may live for years. The disease attacks numerous plants of the mustard family, including various common garden vegetables, flowers and weeds.

Remedial measures. (1) Remove all clubbed roots from the field and burn or bury them; if fed to stock, boil them; (2) plow infected soil deeply; (3) rotate crops; (4) suppress all weeds of the mustard family; (5) apply lime, 75-100 bushels per acre, in autumn before planting cabbages or turnips.

Black rot of cabbages, etc., a recently recognized disease, has been observed in numerous Vermont fields. It is caused by bacteria which invade leaves and stem. The diseased plants are weakened or die of a sort of dry rot. The blackened condition of the invaded veins is the surest sign of the disease. It is not to be confused with the common wet rot. The germs pass the winter in the soil, or in the manure if the diseased plants are fed to stock. They re-enter the cabbage plants through the water pores or insect punctures.

Remedial measures. (1) Rotation of crops; (2) care in use of manure; (3) suppression of cabbage insects; (4) removal and destruction of spotted leaves or of entire plants.

THE DAMPING OFF OF CONIFEROUS SEEDLINGS

L. R. JONES

This malady is a serious hindrance to success in rearing seedlings of pine or other conifers in the nursery. It appeared in the station beds in 1906 and again in 1907, and was restricted to the early stages of development immediately following germination. Soon after the plants appeared above ground the stem tissues browned and shrivelled at or below the level of the soil and the weakened plants fell over and wilted. The diseased tissues were permeated by fungus mycelium. Evidently there is a critical period in the early stage of development of coniferous seedlings when the tissues are unusually susceptible to parasitic invasion.

European publications indicate that more than one fungus may cause this disease. The development of the disease is apparently conditioned upon three things:

1. Conditions of temperature and moisture as determined by the weather and the mode of handling the shades on the seed beds, etc., during the critical period.
2. Previous treatment of the soil, which may tend to increase or diminish its fungus content.
3. The use of fungicides or other applications upon the beds during the critical period.

Much can be done to control this disease by proper management of the beds during the critical period. It is necessary to keep the beds covered in some way until germination begins, but the covering should be removed promptly thereafter, to prevent slender weakly development. Partial shade is required on bright days, but this should be removed in dull or wet weather to keep the surface soil of the beds from remaining too wet. These are matters of personal judgment and experience, of special importance if warm rainy weather occurs during the critical period, when the surface of the beds must be kept as dry as practicable.

The fungus content of the soil at the time of planting is an important factor; hence the practicability of disinfecting seed-bed soil is worth consideration. In greenhouse work, soils are advantageously sterilized by steam. This is apparently impracticable out of doors.

Recourse was therefore had to the trial of chemicals and formalin was chosen as of most promise. At the outset the formalin affected the germination injuriously. The one-half percent formalin solution reduced the germination of the stand 25 percent, and the one percent formalin reduced it by nearly 50 percent. Within a few days, however, conditions began to alter. Those pine seedlings which started made as rapid growth in the treated as in the untreated soil. Where no formalin was used damping off soon set in and at the season's end 90% had perished. In the treated compartment some loss occurred, but it was much less, amounting to only 9% where the one-half percent formalin was used and 7½% where the one percent formalin was used. This outcome encourages the hope that with further trials, using other strengths of formalin and with a longer period between its application and the sowing of the seed, still better practical results may be secured. The possibility of control of the disease in the beds by the application of fungicides during the critical period following germination is studied, but has not as yet passed the experimental stage.

One procedure is, however, certainly commendable, the sprinkling of hot sand on or over the beds immediately following germination. The gains were not large, but sufficient benefit was derived to pay well for the application. Since it is a simple, safe and inexpensive proceeding, it is deemed worth while. Clean sand is used, preferably of coarse texture, and applied as hot as it can be handled, sprinkled on immediately after germination, enough to fully cover the surface of the bed, say one-sixteenth of an inch in depth.

WEEDS

Orange hawkweed or paint-brush (*Hieracium aurantiacum*). A survey of the status of this weed in Vermont, together with special experimentation, led to the statement that it was the worst weed known in certain portions of Vermont, threatening to invade other sections unless precautions are taken.

It is easily recognized by its peculiar hairy leaves and stem and its conspicuous orange-red blossoms. It is a native of mountainous Europe and was introduced as a garden flower. It became well established here since 1870 and has spread most actively since 1880, being most troublesome in the northwestern counties. It rapidly adapts itself to varying conditions and thrives on all soils and at all altitudes. It is a perennial and propagates rapidly both by runners and by seeds. It is most troublesome in permanent grass lands, such as lawns, roadsides and hill pastures. It is extremely difficult to get rid of it when thoroughly established in the pasture. It may be subdued by clean culture where practicable and is quickly killed by salt.

The shrubby cinquefoil (*Potentilla fruticosa*) is widely distributed in the north temperate zone. It is usually a botanical rarity, but in certain sections of southwestern Vermont is "the most aggressive weed invader known, taking almost complete possession of the pastures and pushing even into tilled lands." The plant passes under many local names, grows 1 to 5 feet high, is a pleasing shrub used in ornamental plantings, and propagates as a weed by a great abundance of seeds, which are scattered by the wind like the dandelion, and by sprouting freely from the crown if cut back. Its only serious weed development is in a belt extending from northwest Connecticut through western Berkshire County, Mass., into Bennington and Rutland Counties, on calcareous soils. It has no economic value.

No easy method of combatting it is known. Heavy stocking of pastures recently invaded serves to control it. When fields are completely occupied, burning tops is thought to do little permanent good, nor will mowing do better. Plowing with grubbing and pulling out the larger stools works well, but costs for a well infested area from $8 to $24 per acre. Cattle and sheep browse it somewhat, but will not steadily eat it. Angora goats—used by the station in its experimental fight against this weed—did better and on the whole were effective. Reforestation seems the best solution for thoroughly infested areas, since the pest is killed quickly by tree growth of any kind. It yields but slowly to white pine, fairly to willows and remarkably to butternuts. There seems to be some peculiar root antagonism between the two plants. Wherever butternut trees occur each large tree occupies the center of a clean grassy circle of a diameter considerably exceeding the farthest spread of its branches, while the bases of rapidly growing young trees form the center of an area of dead and dying cinquefoil plants. The butternut should be accorded prominence in reforestation schemes looking to cinquefoil extermination. One young butternut per square rod would probably in ten years kill most of the cinquefoil.

Killing weeds with chemicals.—Gravel walks, etc. Gravel walks, drives, tennis courts and similar places can be kept free from weeds by the use of certain chemicals. The worth of a chemical for such purpose depends on its immediate action as a herbicide and the persistence of its effect. A single application each year should suffice with a good herbicide. The arsenical compounds proved far superior to copper sulphate, potassium sulphid, kerosene, carbolic acid, or sulphuric acid.

The arsenical compounds tested, named in the order of their merit, were: Henderson's fluid weed destroyer, arseniate of soda; Smith's weed killer, arsenic-sal soda mixture. The chief difference between them lay in the persistence of their effect, but all of them endure for one year or longer. Cost, convenience and effectiveness are factors in choice. Using eight gallons to the square rod, they cost per square rod, 40 (Henderson), 11 (arseniate) and 8 (arsenic-sal soda) cents. Henderson's fluid is most convenient to use; arseniate of soda is scarcely less so; arsenic-sal soda mixture is somewhat inconvenient to prepare. While each was effective they may be rated as to endurance: first, Henderson's; second, arseniate of soda; third, arsenic-sal soda. For small areas, in places where cost is a minor item, Henderson's weed destroyer is recommended; for larger areas, arseniate of soda; for very large areas, arsenic-sal soda mixture is enough cheaper to make its use profitable.

Lawns. The coarser and deeper rooted perennials (dandelion, plantain, white daisy, docks) are best combatted by frequent spudding and close mowings, accompanied by proper fertilization, watering and abundant seeding with lawn grass. Shallow rooted creeping plants (hawkweed, crab grass, chick weed) are not thus to be handled. Salt applied at a dry time works well with hawkweed and with chickweed (2 quarts per square rod for latter), the latter when wilted to be thoroughly raked out and liberal amounts of grass seed raked in. Crab grass cannot be easily exterminated. A little may be weeded out; more may in part be got rid of by raking the prostrate seed stalks high enough before mowing to insure the lawn mower cutting them, a practice, which, repeated during late summer and autumn, prevents seed maturation and lessens the extent of the trouble. Reseeding with clean seed with much white clover is suggested.

Kale killing in oats or other cereal crops. Charlock (*Brassica sinapistrum*) can be destroyed by spraying with weak copper sulphate (1 pound to 4 gallons water if flower stalks have appeared, 1 pound to 6 gallons if younger) at the rate of 30 to 60 gallons per acre. The cereal crops are but slightly injured. "Wild turnip" (*B. campestris*) is more resistant. Not over one-half of the sprayed plants were killed. The expense, save of labor, is small and the operation may prove profitable. One should know what kind of kale he has to fight before spraying, for it is doubtful if it is a paying proposition thus to combat the wild turnip.

Killing hawkweed or paint-brush (*Hieracium aurantiacum*). Salt kills hawkweed by drawing water from its tissues. It should be applied dry (not as a brine) upon a hot, sunshiny day, preferably during a period of dry weather, scattering it uniformly, broadcast, so as to come in contact with all the leaves, using from 12 to 18 pounds to the square rod. This application has killed hawkweed and increased the grass crop. The use of salt is recommended only for isolated patches or in soil where cultivation is impracticable. Refuse salt suitable for the purpose costs from $4 to $5.50 per ton. The quick and complete destruction of the weed, even in small patches, is important to prevent its wider spread. Sulphuric acid was tried, but without success.

Impurities in grass and clover seed. Three studies of the grass and clover seed trade were made in 1898, 1900 and 1904. The summarized statements concerning the first two surveys are as follows:

Impurities in clover seed. Most of the newer seeds have been introduced in clover seed. Examinations of 34 samples showed that English plantain, sheep sorrel and wild carrot seed were often and dodder occasionally present. These samples represented the better grades of seed; the lower grades were far fouler than these. A legal enactment requiring a guaranty of freedom from certain weeds is suggested.

Impurities in grass and clover seed. Many farmers pay high prices for pigweed, purslane, kale, plantain and the like, buying them for grass and clover. Clean timothy is purchasable. It is largely a matter of price. Not so with clover, however, since high price does not insure pure seed. Such seed should receive critical examination and be bought discriminatingly.

The third study involved the determination of purity and germination of 735 samples, including 222 timothys, 83 red tops, 103 millets, 134 red and 105 alsike clovers, the investigation being one of the most exhaustive ever made in the United States. The chief evils were:

1. Much inert foreign matter, dirt, chaff.
2. The occurrence of weed seeds.
3. The occurrence of foreign non-weed seeds: (a) legitimate impurities, such as timothy in alsike; alsike in red clover, etc.; (b) adulteration or substitution; yellow trefoil for alfalfa or clover; fescue for orchard grass, etc.
4. Low germination, either: (a) moderately low, due to cheap seed; (b) very low, due to age.

Recommendations are made as to the advisability of more careful seed inspection by farmers for themselves (methods and simple apparatus being suggested) or by the Station for them on request; and as to the wisdom of legislation, citing the nature of laws in other states and quoting the successful Maine law.

SEASONAL INFLUENCE IN CARNATION CROSSING RELATIVE TO SEED PRODUCTION

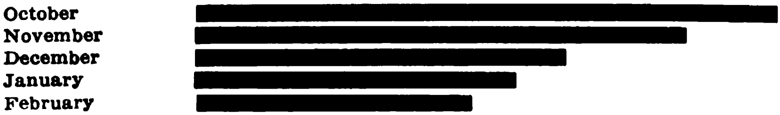
WILLIAM STUART

During the past four seasons the writer has studied the seasonal influence in carnation crossing on seed production. Owing to the fact that but a limited portion of the station greenhouse could be devoted to carnations, the number of plants upon which crosses could be made in any season was relatively small. With few exceptions all data secured during the several seasons shows a fairly uniform decrease in seed production and viability of seeds as the season advances. The condensed results are presented below in tabular and in graphic form in connection with similar data reported by Rudd:

COMPARISON OF RESULTS BY RUDD AND BY STUART

		Crosses made in			
		Nov.	Dec.	Jan.	Feb.
Percentage of successes	Rudd	66.	53.7	44.7	35.
	Stuart	83.3	68.1	60.8	73.7
Average number seedlings per capsule	Rudd	15.5	7.8	6.4	4.6
	Stuart	24.3	19.	13.7	10.9

GRAPHIC REPRESENTATION OF AVERAGE NUMBER SEEDS PER CAPSULE



SUMMARY

Early crosses seem to give on the average:

1. A considerably higher percentage of successes.
2. A much larger number of seeds per capsule.
3. A higher percent of germination.
4. Heavier seeds (although the latter generalization is not insisted on, as the data at hand are not sufficiently ample).

The probable reason why better results are secured from early crosses seems to the writer less due to seasonal influence than to the greater vigor of the plants.

THE MONTREAL MARKET MUSKMELON INDUSTRY

WILLIAM STUART

For years a few Canadian growers of this melon have enjoyed an almost exclusive control of the large eastern markets of the United States. These growers, through carefully selected stock and skilful cultural methods, succeed in supplying excellent melons at fancy prices ($8-15 per dozen wholesale). The crop, however, is an expensive and precarious one to grow, owing to frequent recurrence of unfavorable seasons, and to the extreme care required to grow it successfully.

CULTURAL METHODS

The cultural methods employed by Montreal growers are essentially as follows: The seed is sown in the greenhouse or hotbed from late February to early April; later they are potted up into three or four inch pots, and when in danger of suffering for lack of root space and plant food and the weather is favorable they are removed to sash-covered frames, there to remain until they are almost fully grown. These hotbeds are well constructed, well exposed to the sun, and also protected from cold winds. The frames are often covered with two sets of sash, mats, and board shutters. With such protection, if horse manure is used to generate a sufficient bottom heat and the exposed portions of the frame are banked therewith, the plants may be grown almost as well as in a greenhouse. These frames are moveable sections approximately 12x6, strong and tight with tie rails for the sash to slide upon.

The soil over which these sections are set is ridged up in beds 12-16 feet wide with a one foot center elevation. A trench is dug 2 feet wide, 15-18 inches deep, and filled almost level with well fermenting manure, and a portion of the surface soil thrown over it, slightly more being drawn in where the plants are to be set. The frames are then set in place and covered with sash, which in turn are further reinforced with mats and wooden shutters, or hay or straw with or without the shutters. A 4-6 foot space is allowed between the ends of each section. When the soil over the manure is well warmed up, the warmest portion of some favorable day is selected for planting. Great care is exercised now in transferring the plants from the hotbeds to guard against setbacks from sudden changes of temperature or soil conditions. The coddling process does not cease now. It is simply spread over a greater area and the plants require even closer care than before, for greater attention must be paid to watering, syringing and ventilation, success at this stage being very largely dependent thereon.

As the fruit attains size, it is usually lifted from the soil by a shingle or flat stone, to avoid loss from cracking, rot, etc. Uniform shape, color, netting and ripening is secured by turning the fruit every few days. When the runners fairly occupy the enclosed area the frames are raised a few inches. As the season advances more and more air is admitted until, finally, when the melons are almost full grown, the sash and then the frames themselves are entirely removed.

As each fruit sets its shoot is pinched off one or two joints beyond it. A 15-20 melon crop is considered sufficient from each 6x12 frame. Three or four hills are planted and usually two plants are set per hill.

The melons vary greatly in size. One weighing 44 pounds has been grown. The writer saw one weighing 22 pounds which had been selected for seed purposes. Their average weight range from 8 to 15 pounds, and a dozen averages from 120 to 130 pounds. In exceptional cases some have been shipped weighing 240 pounds per dozen package. The larger melons are apt to be poorer in quality than those weighing 8-15 pounds.

Two distinct types exist, a roundish oblate and an oblong, the first slightly deeper ribbed than the latter. These do not seem to be separated by the growers. It is not at all certain that either type is fixed.

A large wicker basket (clothes basket) is commonly employed in shipping to distant markets. They hold a dozen melons, packed in short fine-stemmed hay, and are shipped without cover, no attempt being made to fasten the melons in place, the express company being held responsible for safe delivery.

A first hand study of this industry leads one to query as to the causes or reasons for the monopoly possessed by Montreal gardeners. American growers have tried to produce the crop, but apparently without continuous success. At any rate American grown melons of this variety cut no figure in the eastern markets. Yet no valid reason appears why American growers should not succeed. Hence the following work was undertaken:

Cooperative work was undertaken with Mr. E. S. Brigham of St. Albans, seed secured from a Montreal grower and sown in the station greenhouse on April 12. Duplicate plantings by Mr. Brigham were made in berry baskets plunged in a hotbed and filled with a rich friable soil. Early in May the plants were shifted into four inch pots and, on May 24 were planted out at St. Albans. Owing to lack of good fermenting manure no bottom heat was supplied; but an abundant dressing of well decomposed manure was used and the frames covered with sash. Owing to the lateness of the season it was thought unnecessary to cover the sash with mats, yet on the night of May 24 the mercury registered 28° F., and the weather during the next few weeks was unseasonably cool. This low temperature, coupled with lack of bottom heat and of mats, severely chilled all portions of the vines near the glass. Growth was materially checked during this prolonged period of cool and cloudy weather, and the setback was never fully overcome.

The warmer weather of latter June entailed a fairly satisfactory growth. By July 30 some of the larger melons were beginning to net. The first ripe fruit was picked August 19, and from that period on several were harvested, mostly much undersized, weighing less than 8 pounds; some of good quality, others distinctly inferior.

The removal of the sash in late August and the heavy rains of early September induced rapid growth and much cracking of both skin and flesh, thus affording favorable opportunity for disease. And on September 12 a few melons were found seriously affected by a soft rot, and two days later a large share of the fruit was found thus affected. The primary points of infection seemed to be those parts which were in contact with the soil or the object on which they were superimposed. Had they been turned frequently during the rainy period less loss would have occurred. The frequent and heavy September rains and cool weather favored the development of this disease and lowered the quality of the healthy melons and retarded the ripening period. Few really good fruit were secured after September 15.

SUMMARY

The Montreal grower succeeds only through the careful observance of the best cultural conditions. His success is, however, directly dependent on the weather conditions obtaining during the growing season. Cold, wet weather during the ripening period materially injures quality and retards ripening. Successional plantings, the first ones in late February or early March, extends the ripening period from mid-July to frost.

A crop which may net $1,000-$2,000 per acre is worth an effort to produce.

Canadian growers seem unable to supply the American demand, even at $10 to $15 per dozen wholesale.

The experimental work at St. Albans was not successful. However, the knowledge secured in the handling of the crop justifies the assumption that there is no valid excuse for continuous failure on the part of American growers to produce these melons successfully. And to the end that a clearer idea of the reasons underlying success and failure may be attained, further work along these lines is contemplated.

MOISTURE AND DECAY LOSS OF HUBBARD SQUASH IN STORAGE

WM. STUART

There is practically no literature upon the subject of moisture and decay loss of stored vegetables. The extent of this loss varies inversely with the conditions of harvest and storage. Different classes of vegetables under identical conditions of storage show widely varying percentages of loss.

The winter storage of vegetables may prove profitable or not according to varying circumstances. Controlling factors are:

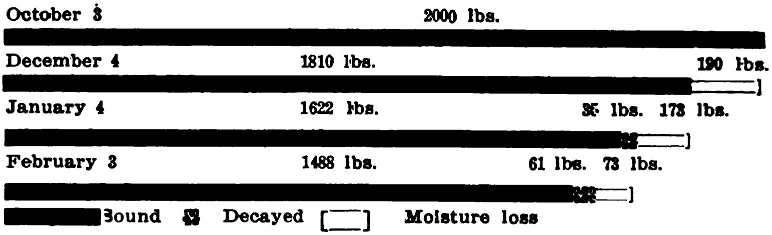
(a) The loss in weight.

(b) The cost of storage, interest charges, etc.

(c) The increase in sales price over that ruling at harvest.

In order to determine the loss sustained in storing Hubbard squash till mid-winter, a ton weighed as taken from the field, was stored on October 3 in a dry and medium warm (50-60°) room. On December 4 it weighed 1,810 pounds, a moisture loss for two months of 9.5 percent. On January 4 it weighed 1,657 pounds, (sound 1,622, decayed 35). A moisture loss of 8.5 percent and a decay loss of 1.8 percent. On February 3, four months from the harvest, the sound squash weighed 1,488 pounds and the decayed, 61 pounds, a moisture loss of 4.5 percent and a decay loss of 3 percent. The total moisture loss during four months was 20.8 percent and that from decay 4.8 percent; total, 25.6 percent.

MOISTURE AND DECAY LOSS OF HUBBARD SQUASH IN STORAGE



Gain or loss from storage.—When the squash were put in storage they were wholesaling at a cent per pound; late in October at 1.5 cents, 2 cents late in December, and in January, owing to unusual scarcity, at 2.5 to 3 cents. At the conclusion of the trial the 1,488 pounds were

sold for $53, an average of over 3½ cents per pound, the net gain by storage being $33 per ton. Market conditions, however, were very unusual. The common price at harvest is $15-$20 per ton, and does not materially increase until January ($30-$40), while during February and March they advance to $50. Hence, even under ordinary conditions the increase in price amply offsets losses from moisture, decay, and cost of storage and leaves a handsome profit.

***Conditions insuring minimum loss in storage.*—To minimize storage losses:**

(1) The squash should be well matured before harvest.

(2) They should be cut or carefully broken from the vine, leaving the stem attached to the squash.

(3) If possible, they should be placed in small piles to ripen and harden up for two or three days before hauling from the field.

(4) They should be hauled in a spring wagon, the box of which is lined with burlap or other material to prevent bruising.

(5) The storage room should be dry and moderately warm at least for the first two weeks to harden up the shells, after which a lower temperature, provided the room is dry, may be maintained.

(6) Finally, squash from harvest to sale should be handled as one would handle eggs. Broken stems and bruised skin are sure to cause decay.

***Summary.*—Squashes properly grown and handled may be held in storage till midwinter or later with a reasonable assurance that the moisture and decay loss will be amply covered by the increased price received.**

HORTICULTURE

Apple growing in Grand Isle County. A survey of this industry made in 1896 led to the following statement: Grand Isle County is increasingly devoted to commercial apple growing, and the success already achieved encourages its further extension. The crop of 1896 has been larger than in any previous one (40,424 barrels of marketable apples). The number of bearing trees is 34,885; and of trees still too young to bear, 17,229. Sandy or gravelly soils are preferred; budded nursery stock, two to three years old used, though some prefer native or hardy stock and top grafting; all commercial orchards are systematically cultivated; barnyard manure is used; windbreaks are found valuable; spraying is an accepted practice, apparatus and methods varying; and top grafting is frequently practiced. The fa-

vorite varieties grown are Northern Spy, Rhode Island Greening, Baldwin, Fameuse, Talman's Sweet, Pound Sweet, Golden Russet, Ben Davis, Yellow Belleflower and Arctic. They are picked directly into barrels and usually sent to market early, though some are held in storage.

A further and more systematic survey was made in 1901 with several objects in view. (1) to make a complete inventory of all varieties; (2) to examine specimens and discover whether or not they were as represented; (3) to name unknown apples or those grown under incorrect names; (4) to determine what varieties were best to plant; (5) to discover varieties of local origin, distribution and reputation; (6) to determine the origin of the various varieties; (7) to determine the varieties which maintained themselves continuously for years and to obtain the history of those which have succeeded or failed as a contribution to the study of the working of the laws which underlie plant distribution.

Grand Isle County is a most favorable district for a study of such problems. It is made up entirely of islands and one large peninsula in Lake Champlain, and the entire county is set off from its neighbors. Its people have always lived at home among themselves to an unusual degree. It was opened to railroad communication in 1901.

The best apple market varieties grown are Rhode Island Greening, Fameuse, Northern Spy, Ben Davis, Baldwin. The various varieties are thus placed as to origin. (1) Many are the common apples of all New England and New York State; examples, Baldwin, Northern Spy, Rhode Island Greening. (2) some derived from the vicinity of Boston; examples, Jacob Sweet, Harvey and Hawley. (3) some are derived from the lower Hudson valley, more particularly through the Downings; examples, Peck's Pleasant, Newton, Pippin, Spitzenburg and Grimes. (4) the Province of Quebec; examples, Fameuse, Pommene, Grise. (5) several have come in as a result of the survey for commercial varieties for cold and exposed situations, more particularly through the efforts of Dr. T. H. Hoskins of Newport; examples, Longfield, Scott, MacMahon, Yellow Transparent, Wealthy. (6) "the hustling, modern fruit tree agent"; examples, Beach, Stark, Legal Tender, Arctic, Fishkill.

Two separate apple planting movements were noted, one by the original settlers planting haphazard varieties, the other the planting of orchards for profit. The latter movement had two distinct phases: (1) the planting of commercial varieties, no matter of what kind; (2) the adoption of the strictly commercial sorts. Twenty-eight pages of apple notes and descriptions are given in the text, listing 116 varieties with many synonyms.

Apple growing in Addison County. A survey of the number of bearing trees in 1901, of the crops of 1900 and 1901, with statistics as to orchard culture, the use of the wind breaks, the soils used, the varieties grown, and practical suggestions as to soil cultivation, fertilization, spraying, pruning, varieties and marketing. It was shown that but one-fifth of the growers cultivated their orchards; that about one in four used fertilizer; that only 4 out of 40 representative growers sprayed their crops, and that but five or six orchards were guarded by wind breaks. A long list of varieties were found growing, the most popular being the Greening, Baldwin, Northern Spy and Fameuse.

Pollination of apples. Apples are often self-sterile, and need cross-pollination. In trials made by this station practically all the varieties tested proved self-sterile, including such common sorts as Baldwin, Fameuse, Esopus, Northern Spy, etc. In order to secure cross-pollination of two varieties care must be taken to select such as blossom at the same time. Bees are the chief agents in pollen transfer. The wind does not transport the pollen to an appreciable extent.

Apples of the Fameuse type. A survey of the Fameuse type, its essential variation and pomological status, with discussion and notes of sundry varieties. Fameuse is the type of the Fameuse group, which includes several other varieties closely resembling it, such as McIntosh, Shiawassee, etc. The Fameuse type is of great commercial importance. It has many marked good qualities and few defects. Fameuse has had a long and interesting history. It probably originated in the 1600's in the French settlements on the St. Lawrence, was distributed widely, though chiefly by seeds, and was first planted in Vermont at Chimney Point about 1700. Fameuse varies greatly, largely because propagated by seed, and partly because of bud variation. There are several important varieties of this type, while hundreds of other seedlings, recognized as of the same group, have not been generally propagated.

Hardy apples for cold climates. The limit of successful apple culture is moving steadily northward. Factors in this progress have been the crab apples, dwarf apples, the Russian varieties, the selection of native hardy seedlings and the adoption of better orchard practice. The present limit of the Baldwin and the Rhode Island Greening in Vermont is shown by a map. To grow a given variety further north a protected situation with a favorable exposure should be chosen and top grafting done upon a very hardy variety growing on its own roots. Varieties recommended where hardiness is important are: Yellow Transparent, Red Astrachan, Longfield, Oldenburg, Fameuse, McIntosh, Wealthy, Scott Winter, Pewaukee, Arctic.

Bridge-grafting a girdled apple tree. Bridge-grafting is the only way surely to save badly girdled trees, and in most cases is a comparatively simple process. Where not completely girdled, mounding soil over the injured portion to exclude air and keep the wounds moist, will often serve to repair the injury.

On the winter injury of apple trees. In cases of winter injury like that experienced in 1904 there is little to be gained by the hasty removal of the greater portion of the head of the tree. In other words, severe pruning is inadvisable and probably more often injurious than beneficial. Pruning operations under such circumstances are better deferred until late in the growing season or until the next spring. Winter injury may be avoided by keeping the tree in a thrifty, vigorous condition. Weak, unhealthy trees are less able to stand extremes of temperature than thrifty ones.

Notes on the winter killing of twigs and buds. A discussion of the anatomy of twigs as related to hardiness, relation between dessication and winter-killing, and between maturity and winter-killing, with remarks as to heat absorption or reflection. It is held that (a) the inherent power of cold-resistance possessed by the plant; (b) the maturity of the wood, and (c) the dryness of the soil and atmosphere, with many minor causes cooperating are factors in the result.

Hardiness of plums. "A general study of the hardiness of the different species of plums in the United States has resulted in the fairly close determination of the northern limits of successful cultivation of typical varieties such as the Lombard and Bradshaw (European), Burbank and Kelsey (Japanese), and of the Wildgoose, Miner and Chicasaw groups. The Americana plums are found to be hardy as far north as any fruit trees can be grown."

Field notes on cherries. Explanatory statements as to varieties, descriptive, historical and nomenclatural. A memoranda of desirable varieties, with suggestions as to culture, soil cultivation, pruning, stocks, hardiness, diseases and insects, picking, marketing, etc. The following are recommended: Morello, Montmorency, Brusseler, Braun, Wragg, Bessarabian, Schatten Amarelle, Griotte du Nord, Juneat Amarelle. "There is a ready and profitable home market in Vermont for twenty-five times the quantity of cherries now grown—and cherries are easier to grow than potatoes."

Home grown grapes in Vermont. Cultural memoranda and variety notes. Good grapes for home use may be easily grown in Vermont. A warm site must be chosen and the vines covered in the fall. The common horizontal arm system furnishes the best method of pruning and trellising. Summer pruning is practicable within narrow limits. Early varieties should be grown, and the fruit left on the vine as long as possible. Several leading varieties are described and the results of tests given. The following are recommended: Black, Moore's Early, Worden; red, Moyer, Brighton, Wyoming Red; white, Green Mountain.

A home fruit garden. A discussion of the inception, planting and caring of home fruit gardens with suggestions as to choice of location, soil preparation, methods of obtaining trees, setting, varieties for choice of apples, pears, plums, cherries, grapes, bush berries and strawberries, with remarks as to their cultivation, fertilization, pruning, and winter protection.

EXPERIMENTS IN DRUG PLANT CULTIVATION

S. C. HOOD

During the season 1993 to 1906, inclusive, the United States Department of Agriculture, with the cooperation of the Vermont Experiment Station, has carried on experiments in the cultivation of drug plants. This work was taken up for the purpose of finding out if it is possible to produce, with a fair profit, many of the crude drugs which are now brought to this country from foreign parts and also to bring under cultivation certain wild medicinal plants which are becoming scarce. The following table shows the importation of some of the more familiar drugs for the fiscal year ended June 30, 1905:

Opium and other poppy products	$2,352,593
Dandelion root	4,562
Digitalis leaves	3,600
Yellow dock root	7,500
Thyme oil	39,839
Mustard seed	189,894
Burdock root	4,000
Quackgrass root	12,500

As will be seen, many of these plants are common weeds in Vermont, while many others are imported from countries with a climate not much different from that of New England.

SUMMARY

The results of these experiments have shown:

1. That root drugs, such as burdock and yellow dock, can be grown on Vermont farms with a good margin of profit where the land is low priced.

2. That Seneca snakeroot can be cultivated and the supply of this important drug kept up, even though the wild supply is exhausted.

3. That certain plants, such as belladonna, will not mature during the short Vermont season.

4. That sage, digitalis, and lovage will not survive the winter in Vermont, even though they make good growth the first season.

5. That in view of the high price of labor in Vermont the culture of herbs, such as catnip, thyme, lobelia, pennyroyal, and of seed, such as caraway, fennel, and coriandèr, is not likely to prove profitable.

6. That at present the cultivation of poppies for the capsules and seed is not promising for Vermont, but that there may be a future for these for the direct production of morphine.

7. That the province of the plant breeder extends just as much to drug plants as to other economic plants. That the alkaloidal and oil content can apparently be increased as readily by selection and by the use of fertilizers as can the protein, starch, or sugar content; and that larger yields per acre can be obtained, also disease resisting types secured·by simple selection.

INSECTS AND INSECTICIDES

Household pests. Brief descriptions of the buffalo or carpet beetle and of clothes moths. The following remedies are suggested: For the buffalo beetle, the use of rugs instead of carpets, tarred paper next to the floor, benzine poured upon the edge of the carpet, or corrosive sublimate solution upon the edge of the carpet, steaming the carpet, the use of benzine. Insect powder is said to have no value. For clothes moths: enclosure of clothes in tight paper bags before the moths begin to fly in May, the sprinkling or spraying of infested articles, drawers, etc., with benzine or with bisulphid of carbon.

Notes concerning sundry pests, including *Dermestes lardarius*, the red-legged ham beetle, ants, bedbugs, flea, house flies and mosquitoes, with remedies.

Insects injurious to the elm. Notes on mourning cloak butterfly, tussock moth, canker and fall canker worm, fall web worms, elm borers, elm leaf beetle, May beetle, June bug, plant lice, elm gall and cockscomb gall lice. Descriptions and in some cases life histories are given. Banding trees is suggested for tree canker worms, gathering and burning the webs for the fall web worms. Arsenical sprays are also effective. Digging for the borers is suggested, though not very effective. Arsenicals, kerosene emulsion and carbolic acid solutions are advised for use against plant lice.

The round-headed apple tree borer. Historical and descriptive notes, together with preventative measures. The exclusion by the means of heavy paper or fine wire screen is effective only when properly done. Repellants are of service only when persistently used, and at best do not insure absolute protection. Patent washes are apt to prove injurious to the trees. Digging out with knife and wire is effective, but laborious. Carbon bisulphid intelligently used may be serviceable, but is a dangerous remedy in careless hands.

The white grub. A survey of life history, including egg deposition, larva formation, the beetle, experiments as to destruction (fungi infestation, refrigeration, starvation, dessication, insecticides, ashes, bisulphid of carbon, kerosene emulsion, ants, frogs, sundry animals and birds, etc.)

Early spring applications of insecticides for the oyster-shell scale. Early spring applications do not serve to eradicate the scale. Summer treatment of infested trees with dilute kerosene emulsion, whale oil soap or tobacco infusions, soon after the young have hatched, is more effective.

The occurrence and distribution of San Jose scale in Vermont. The San Jose scale may rapidly increase despite the rigor of Vermont winters. Its wonderful reproductive powers make extermination a serious problem. The present restricted infected area makes feasible more drastic measures than are commonly employed. Orchardists should carefully scan the trees for scale and report suspected cases at once to the station. An orchardist whose trees are infested with oyster-shell scale may temporize, spray or destroy; but he who finds San Jose and fails to report it harbors a serious menace. Lime-sulphur wash applied in the early spring is the best known remedy. Commercial preparations ("Scalecide," "Target Brand" and the "Rex-Lime-Sulphur" washes) give fairly good satisfaction. Badly infested trees cannot be entirely freed by spraying and should be cut down and burned.

Bug death. Both "bug death" and "laurel green" have value as preventatives of insect injuries to potatoes. They were used in amounts far in excess of those recommended as practicable under commercial conditions. "Laurel green" destroyed the Colorado beetle and lessened the injury from the flea beetle, but the foliage was seriously poisoned by free arsenic. "Bug death" seemed to protect against both, since the vines "were kept in better condition than were any others except the bordeaux (treated) rows." "Bug death has real virtues and does not hurt the foliage." However, "bordeaux-paris green mixture is far superior to any other substance as yet tested as a combined insecticide and fungicide for potatoes."

Arsenicals used against miscellaneous insects. London purple, paris green and white arsenic (1 pound per 60 gallons water) used against aphis on apple trees were not entirely effective; used against tent caterpillar were usually effective; used against codling moth after the apples were as large as marbles and turned downwards, were of no service.

Analyses of insecticides. Analyses of arsenicals, "bug death," herbicide, "laurel green" and other proprietary materials. Laurel green consisted mainly of copper; bug death was found to be roughly three-fourths zinc oxid, one-eighth lead oxide, one-eighth iron and alumina oxides; "herbicide" proved to be a concentrated solution of some alkaline arsenite; green arsenite and paris green appeared to be the same thing.

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BULLETIN 137; ABSTRACT TWENTIETH ANNUAL REPORT, 1906-07
CROPS, FORESTRY, STOCK FEEDING, DAIRY HUSBANDRY

JOSEPH L. HILLS

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INTRODUCTION

Following the precedent established four years ago, abstracts of the twentieth annual report are presented in this bulletin and the preceding number in which the matters of more direct practical interest are briefed. Recipients of either bulletin desiring to receive the full report have but to ask, specifying by its number—twenty.

The twentieth report marked the close of as many years of station existence. Since preceding issues are mostly out of print, but frequently called for, it seemed both desirable and appropriate to gather therein brief resumés of such studies as possessed more than ephemeral interest. In the two abstracts presented are statements:

No. 136—Concerning plant diseases, weeds, horticulture, insects and insecticides.

No. 137—Concerning crops, stock feeding, and dairy husbandry.

The writer is responsible for the editing of the briefed matter. The articles to which authors' names are attached are condensed from the new matter appearing in the twentieth report. The material as printed in the report which is condensed from previous publications shows authors' names and gives references to the original publications. Owing to exigencies of space, only the barest outlines are given.

CROPS

The proper time to harvest corn in Vermont. Several different trials of this matter have been made. In 1893 Sanford and Red Cob corns were cut August 13, 29, September 13, 28, and (Red Cob) November 17, weighed, sampled and analyzed. The practical outcome may be stated as follows: (1) the corn plant increases its weight and value as it grows older, but (2) the carbohydrates increase so much faster than the protein that its quality decreases as it grows older; yet (3) the great increase in weight far overbalances the quality loss. (4) Green corn fodder usually weighs the most just as the kernel begins to glaze; but (5) it does not then contain as much dry matter as when fully glazed and mature; hence (6) varieties that will mature should stand till ripened, while those which do not should stand as long as they are safe from frost. (7) The increase in dry matter after the kernel has begun to glaze is mainly starch and kindred nutrients; hence (8) it may not always pay to run frost risks for the sake of the increased weight, particularly if the crop is to be stooked. If ensiled, the crop can be grown closer to frost without danger.

In 1900 and 1901 Sanford, Red Cob, Leaming and a Virginia dent were planted. Sanford corn is a relatively small flint corn, largely grown and favorably known throughout northern New England; Red Cob, a larger variety which occasionally matures at Burlington; Leaming, a yet larger variety, popular in southern New England, characterized by excessive leaf growth; the Virginia corn (variety unknown), a large, impressive-looking dent corn.

The larger corns produced from 50 to 70% more gross weight than did the Sanford, but averaged only 10% more dry matter, and that was less mature. The several crops were ensiled and fed. When the cows were changed from Sanford silage to that made from the larger growths, shrinkage of milk flow ensued unless an increased amount of silage was fed. The Sanford silage was a shade richer in protein and much richer in carbohydrates than that made from the larger growths, doubtless due to its greater maturity.

The large corns look impressive, but they yield but little or no more actual food matter than do some smaller varieties. The farmer has, moreover, to harvest and house large tonnages of water which may generally be procured cheaper in other ways.

The best method of harvesting corn. For three years this query was put to the cows:

(1) 1891. Three fresh cows were fed 16 weeks on either silage or corn fodder from the same piece. Equivalent amounts of dry mat-

ter being fed, the gains from feeding silage were 9% milk, 6% solids, 4% fat. More product was obtained from a pound of dry matter when ensiled 6 times in 9. The silage was less laborious to feed.

(2) 1892. Twelve cows were fed 20 weeks with hay, grain and the corn plant either (a) ensiled, (b) stooked, (c) husked, the stover ensiled or (d) husked, and the stover stooked, the ears being ground and fed with the stover in (c) and (d). Every cow was fed the corn plant harvested in each of these ways for at least four weeks and was fed it when harvested in some one of these ways twice for four weeks during the first and the last feeding periods of the season. Thus, for example, 3 cows were fed silage in November and March, were fed corn stover plus the proper amount of ground ears in December, were fed stover silage plus ears in January, and were fed corn stover 82 pounds for each 100 pounds produced by silage. Since opportunity to record her verdict as to the economy of the four harvesting processes.

(3) 1894. Fourteen cows were to be fed in the same manner as above outlined under (2); but owing to the unpalatable dry forage harvested in that extremely droughty year the cows would not eat enough of it to maintain their flesh; hence 6 cows were fed (a) silage and (c) stover silage (with ground ears).

The combined and condensed deductions drawn from (2) and (3) may be stated as follows:

1. From 18 to 20% dry matter was lost by each method of harvest.

2. The losses fell most heavily on the nitrogen-free extract and ether extract, but slightly on the ash and fiber. The protein losses approximated 10%.

3. The stooked fodder losses increased as the winter progressed.

4. It cost less to put dry matter in the manger by way of the silo than by way of the stook. The time and money spent in husking and grinding the ears (16 cents per bushel) was wasted, since better results were attained when the ears were left on the stalks.

5. The silages were better relished than were the fodders and the cows did better on them.

6. In 1892 the stover silage ration produced at the rate of 82 pounds of milk, the corn fodder ration at the rate of 92 pounds, and the corn fodder (ears and all) in February. Hence each cow had her the quality was unaffected the proportions were the same as regard to the yield of butter. In 1893 there were 91 or 92 pounds of milk and butter produced by a given amount of dry matter in the stover

silage and meal ration, as compared to 100 pounds produced by the same amount of dry matter in the whole silage ration.

7. The whole silage lasted longest each year. An acre of whole silage equalled in milk producing power 1¼ acres ('92), and 1 1-10 ('94) of stover silage and ears, 1 1-12 acres of corn fodder, 1¼ acres of corn stover and ears.

The effect of frost on corn for silage. Twenty-one cows were fed experimentally for nearly six months on silages made (1) from immature corn, (2) from immature corn very slightly frost touched, (3) from a mature corn very slight frost touched, and (4) from a mature corn hard frosted. Not every cow was fed each of these silages; but they all contributed to the solution of the problem as to the effect of frost on corn for silage. The results of the trials were held to warrant the statements that: (1) "More dry matter was eaten when the mature silage was fed; that (2) the quality of the milk made when the silage from the frozen corn was fed was depressed slightly; that (3) the total solid and fat yields were slightly depressed when the ration containing the frozen corn silage was fed; and that (4) the products per unit of consumption were depressed when the more mature silages were fed, owing to the greater consumption but smaller production." In these trials the effect of frosting corn, and yet more of freezing it, appears very slightly to have been to depress its feeding value. In view, however, of the fact that from 6 to 15% more dry matter was harvested as a result of the two weeks' longer crop growth, the slight depression resulting from the feeding of silage from frozen corn is a negligible quantity. No ill result on the butter product was observed. Silage made from frozen corn seems to keep well in a good silo. It would appear that the testimony of this trial favors the running of frost risks to gain a greater maturation.

Large and small stooks of corn. A ton of frosted corn fodder put up in two large stooks, lost 14% dry matter from October 24 to December 10, as compared with 15% loss from a ton put up in 6 to 8 stooks.

Losses of food matter in stooking corn. Immature (in the silk) corn, stooked August 9, standing exposed four months as do ordinary stooks, lost 29% dry matter, 11% ash, 16% crude fiber, 21% protein, 38% nitrogen-free extract, 67% ether extract. The outcome is commended to the study of those who believe that there is nothing but water lost from stooked corn.

Fowl meadow grass. This is the best native grass for use on wet soils. It now occupies large areas of flowed intervals and its value for such situations has been long known. Closely resembling red top it is softer, has a more slender habit and lighter color. It may be cut at any time from July to October at will.

Several years' trials indicate the correctness of the following statements: Seed of good quality is produced abundantly, yielding 6 to 7 bushels per acre, and the threshed hay is almost as palatable as that cut earlier. Growth from seed is easily obtained, but the grass requires two or three years to fully establish itself.

The yields from natural overflowed interval meadows are 1¼-2½ tons per acre, exceeding those on adjacent timothy pieces. Timothy tends to decrease in quantity and deteriorate in quality, owing to the displacement of the timothy by the sedges. The yield increases up to seeding time, and since the quality remains good it may be cut late. The hay is of good quality and as well relished as is upland hay.

For sowing on wet soils a mixture may include variable proportions of red-top, fowl meadow, timothy and alsike clover. If the soil is favorable, fowl meadow will form an increasing proportion of the crop until in 3 or 4 years it will entirely replace the other grasses and thereafter persists. Sowing in midsummer without grain or other nurse crop is advised.

Alfalfa in Vermont. Alfalfa is a plant of the clover family, larger, longer lived and in many ways superior to common clovers. It is richer in digestible protein and a better soil and manure pile enricher than is any other economic plant. It is well adapted for use as hay, silage, and soiling. It has been of late increasingly grown in northern latitudes, though little success has been met in New England outside of Vermont. In Quebec, Ontario and northern and central New York it has succeeded at several points.

Fifty-six trials are summarized, with permanent successes 12, temporary successes 10, success at outset 8, seeming success 5, questionable 7, failure 14. Two-thirds of the successes attained with this crop were located within the Champlain valley. Its preeminence in alfalfa growing seems to be due to the character of the farming in that section and to the nature of its soil. Failures may generally be ascribed to one or more of several unfavorable soil or weather conditions, to weeds, to disease, or to seed which either is inferior or from an unsuitable source. Suggestions are offered as to means of combatting these difficulties and the collection of home grown seed is commended.

Alfalfa culture in Grand Isle County. Alfalfa succeeds admirably in Grand Isle. The soil and climatic conditions favor, particularly the good natural surface drainage of a basic soil rich in lime and potash. It was first grown in 1889 by Mr. S. G. Macomber, and is now widely used. Everyone who has tried it on suitable soil has had fair success, and pronounces it profitable, usually deeming it the most profitable crop he can grow. It is succeeding best on gently sloping gravelly or slaty clay loams with good natural underdrainage. Winter killing is attributed to standing water or to the formation of a surface sheet of ice.

The methods of culture employed are briefly: Thorough preparation of soil; freedom from quack (witch) grass; seeding with oats or barley in spring as early as possible, using 20 pounds seed; no further treatment the first year save grain harvest; cutting thrice yearly in succeeding years; a light annual top dressing with commercial fertilizer; no harrowing, discing, etc. Quack grass and dodder have been the most troublesome weeds. The crop is hayed, being but little more difficult to cure than red clover. In only one case has a full stand continued five years. No seed or soil inoculation is practiced or seems needed. The crop is held to be so desirable that, though winter killed the third year, yet would it be deemed profitable.

A poisonous plant, the common horse tail (*Equisetum arvense*). This plant is seriously poisonous when fed in hay to horses. Its nature is described, the extent of the trouble indicated, symptoms shown, the affecting conditions and the extent of the poisoning process are discussed and treatment suggested. It is a common native plant, thriving best in sandy or gravelly soils which are moist a part of the season or with a relatively high water table. It is quite apt to grow in sandy, overflowed interval meadows, mixed with wild grasses and "polypod brakes." No evidence is at hand indicating that cows are affected; sheep appear to be less quickly or easily injured; but horses are commonly poisoned.

Feeding experiments were made during two winters, using five horses. All were killed by the feeding. Careful records were made of symptoms and of post-mortem results. The essential symptoms are: swaying and staggering, inability to stand, rigidity and convulsions of the muscles. Young animals succumb more readily than older ones; grain-fed animals resist the poison longer than do those not grained. The plant, despite its toxic qualities, is eagerly eaten by horses. There is no evidence that when eaten in the green state it is poisonous. Treatment: discard the poisonous hay; purge and follow with nux vomica.

Miscellaneous fodder crops. Many different forage crops were grown experimentally in the first decade of the station's work. The general results may be summarized as follows:

LEGUMES. *Clovers* (red, mammoth red, alsike), averaged 1½ to 2 tons hay to the acre, white clover less than a ton to the acre. Attempts were made during several seasons to secure a growth by sowing crimson clover at different times during the summer and early fall, but all were unsuccessful. Only under exceptional circumstances can it be carried from fall to spring. As an annual spring sown crop it does well (8 tons green fodder).

Soy beans. Three varieties grew well, making from 2 to nearly 12 tons of green forage and from ⅝ to 3 tons of dry matter. Again it yielded 5 tons green fodder, 1.25 tons dry matter. This crop is well relished, green, ensiled, or hayed. The green and black varieties are the best annually cultivated leguminous crops tried here.

Flat pea (*Lathyrus sylvestris*). This perennial made a spindling growth in 1894, a waist high, tangled mass in 1895 and 1896 (6¾ tons of green fodder, 2 tons hay, ½ ton protein per acre in 1895), and was largely killed out by witch grass in 1897. The crop of 1896 was ensiled, but not relished. The green fodder is eaten reluctantly.

Cow peas. Thirty-seven farmers made 30 reports on crops of medium to good growth as follows: Failures 12, indeterminate 6, possibly desirable 5, inferior to corn 11. The cow pea is not a plant likely to prove of benefit so far north as Vermont. It presents no advantages over soy beans, and yields less dry matter and protein. The latter are harvested with greater ease and are well relished.

Oats and peas. Nineteen tons green forage, 5 tons dry matter; a well-known and too little grown combination.

Peas, oats and rape. "Good growth, more than half * * * rape."

Vetches with oats. 7¼-10½ tons green forage, 2-3 tons dry matter. "Experience for several years does not lead us to consider them equal to peas and oats."

Villous vetch (with soy bean; with horse bean; with oats and rape). "Fair growths, mostly of vetch save in the third combination, which grew 3½ tons green forage."

Sweet clover. Very welcome to bees, refused by cattle.

Seradella. 2.5 tons green forage per acre; a small plant of low growth but dense foliage; not readily eaten at the outset; fairly rich in protein; not a promising forage crop.

Horse beans. "Not successful, growth small."

MILLETS. *Japanese millets.* 1893, "Did not do well; they were planted in a particularly weedy spot and had a hard struggle." 1895: yielded from 8.5 to 19 tons of green fodder and from 2.5 to 5.25 tons of dry matter. Rapid growers; an impressive showing; protein content very low; better results by broadcasting than by drilling; readily eaten.

Hungarian. Grew less luxuriently than Japanese millets; richer in protein.

MISCELLANY. *Green barley,* sown July 31, was fed from October 17 until late November, being green and well relished until Thanksgiving. It yielded 1½ tons of hay per acre.

Winter rye. Sown in September, cut in mid-May with the heads just beginning to show; carried 12.75% dry matter and 2.2% protein, being thus richer in this nutrient than is clover. Eaten with relish. Ten days later, when beginning to blossom, the stalks became tough and it was rejected. Neither did it fare better as silage.

Kafir corns are non- saccharin sorghums largely grown in semi-arid regions because of their drought-resisting qualities. They grew 4¼ and 4 tons of dry fodder to the acre, formed seed heads but did not mature seed. The fodder was well relished, and the dry matter was closely similar in composition to that of corn. "There seems no good reason for growing kafir corn in a climate where Indian corn can be raised successfully."

Prickly comfrey. First season cut three times; yielded about 1½ tons hay per acre; second season cut four times; yielded at the rate of 4¼ tons hay per acre. Readily eaten but difficult to harvest.

Japanese buckwheat was much in the public eye in the late eighties. A crop grown in 1888 yielded at the rate of 2 tons of hay per acre. Cows did not relish it, but horses ate it readily. A crop grown in 1889 yielded at the rate of 41 bushels per acre. Sown May 8, it yielded over 1⅔ tons dry matter per acre in 11 weeks when in full blossom and 2 tons when ripe a month later.

White mustard is remarkably rich in nitrogen. It is used by some for green manuring, on the ground that it helps to keep down the weeds, improves the soil and tends to prevent soil washing. It is not eaten by cattle to any extent.

Japanese radish. A large growth of tops, but almost no roots. Cattle would eat neither.

Sunflower. "Heads produced 1.5 tons of dry matter, including over 600 pounds fat."

Silage corn. Sixteen varieties, mostly dents, sown May 30, cut October 1, yielded at the rate of 6 to 11 tons of immature green forage per acre.

MAPLE INVESTIGATIONS*

*Bulletins 26, 103 and 105 are in ample quantities and will be sent on request.

THE VERMONT STATE NURSERY FOR FOREST TREE SEEDLINGS[1]

L. R. JONES

THE DISTRIBUTION OF SEEDLINGS IN 1907

An immediate effect of the passage of the act establishing a Forest Nursery was a stimulation of popular interest in the possibilities of forestry plantation. Requests were received for far more seedlings than were available for distribution; hence late requests were entirely declined and large orders filled only in part. From various sources white pine and black locust seedlings were offered for sale in limited amounts as listed on page 46 of bulletin 127, and shipped to twenty parties, five each in Windsor and Orange Counties, three in Rutland, two in Lamoille, and one each in Caledonia, Windham, Chittenden, Addison, and Washington Counties. These were accompanied by directions for unpacking, for setting, and for caring for the seedlings in the nursery row, (soil, beds, spacing, planting, subsequent care and a brief statement as to permanent planting. Personal visitation was made to several of the plantations in the fall and their condition noted. In order to secure data as to success or failure inquiries were addressed to each purchaser as follows:

I. Did you receive the shipment promptly and in good condition?

II. Did you plant promptly, or was there delay? If so how long, and in what way were the trees stored meanwhile?

III. Did you plant any in nursery row (i. e. in garden or other beds)?

IV. In what condition are these plants now? (Sept. '07).

V. What disposition shall you make of these transplants next spring?

VI. Did you place any in permanent plantation?

VII. In what condition are these plants? State percentage of loss.

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[1] The establishment of this enterprise was discussed in bulletin 127 (April, 1907), wherein it was stated that the last General Assembly passed an act providing that, for a term of five years, five hundred dollars be paid annually to the station to aid in the establishment and maintenance of a nursery for the propagation and distribution at cost of forest tree seedlings; the station to provide at its own expense necessary land and expert supervision.

VIII. Do you plan to fill vacancies where seedlings have died?

IX. Are you planning to plant in 1908?

X. Have you suggestions to make, based on experience this year?

ANSWERS RELATING TO 2 YEAR OLD WHITE PINE SEEDLINGS

I. The goods were received promptly and in good condition.

II. Two-thirds of the recipients planted within 24 hours of arrival and most of the others within a week. In one case they were kept two weeks and in another nearly four before planting, being trenched or "heeled in." While this delay is undesirable it was not seriously injurious. A 10% loss, mostly attributable to delay in planting, was reported in the second case.

III. The directions recommended placing 2 year seedlings in the nursery row for a year or more. Most buyers thus placed them; some placed part thus and the balance in the field; a few put all in the field. Where set in the nursery they were planted in rows four to six inches apart, and given clean culture.

IV. Considering the lack of experience and the unusually trying midsummer heat, the results were gratifying. Two-thirds reported a loss of less than five percent, and with most others the loss did not exceed ten percent. Where it exceeded this there was generally evident reason for it as; a dry southern slope and unusually parching heat killed many plants before they had established themselves; a heavy application of commercial fertilizer upon the beds, etc.

V. Those who set the seedlings in nursery are about equally divided in their plans. About one-half of the plants are to be carried another year in the nursery row and about one-half are to be transplanted to the field in 1908.

VI. Some set a portion and a few set all, mostly in permanent plantation, 6x6. The grub hoe or spade was used and no difficulty experienced. The situations planted included worn out hillside pastures, recently cut woodland, or sprout land, and open places in young forest growth.

VII. In spite of the small size of the seedlings and the lack of experience in planting, three-fourths of those who set the seedlings in permanent plantations report good success. In general 90 percent of the seedlings survived. Two expect to collect native stock for seedlings thus treated lived. In one case the majority were lost, due to planting on a dry hillside followed by a severe drought; in another 20 percent were lost because the planted area was in a pasture and the cattle stepped on the plants.

VIII. Practically all who started permanent plantations propose to fill out vacancies where seedlings have perished.

IX. Three-fourths of those ordering in 1907 propose to place another order in 1908.

X. Several helpful suggestions were made: (1) that the directions issued urge prompt planting; (2) that transplanting be done as early as practicable; (3) that cattle and other stock be excluded; (4) that attention be called to the fact that transplanting native seedlings can be practiced cheaply and successfully where they occur plentifully; (5) that publicity be given to State Nursery offerings and to the desirability of reforesting waste lands.

The outcome meets all reasonable expectation. Requests were far in excess of supply and indicate that the public is ready for the work. Purchasers succeeded well, showing that it is practicable thus to handle seedlings. Those who made a beginning propose in most cases to continue, showing that the movement may be expected to gain in momentum.

LOCUST SEEDLINGS

Some 5,000 locust seedlings were sold. These are recommended for small trial plantations, since the question of local adaptation and of injury to the borer remain to be answered by experience. They were reported in good condition at the end of the summer, making rapid growth, with but a small percentage of loss, save in one case where many were killed by a severe drought soon after planting. There is no reason to doubt the general practicability of handling locust seedlings.

Statements concerning offerings are made yearly in the spring bulletin.

COLLECTING WHITE PINE SEED

White pine is a native of America only. It has been cultivated in Europe as a forest tree for many years, chiefly in Germany, and much of the seed offered even in the American market comes from Germany. There is reason to believe, however, that the highest success both in raising the seedlings and in the subsequent growth of the plants is conditioned upon the use of freshly collected seed from our native trees. There is experimental data to show that with some other trees, at least, seed from a more southern source or strain, or from a milder climate, does not produce as hardy stock as does the native or that from a northern locality. While this has not been experimentally established for the white pine, it is at least the reasonable course in this State Nursery work to use native seed so far as obtainable. Appreciating the fact that 1907 was to be a "seed year" for the white pine in this section, a circular was issued through the press of the State about the first of September calling attention to the desirability of collection of seed. Following this announcement a number of parties undertook to collect pine seed. One man collected fifty bushels of cones, and extracted therefrom some fifty pounds of seed. Several others gathered smaller amounts. Employees of the State Nursery collected on the University farm fifty bushels of cones. It will be one aim in this movement to encourage systematic collection of pine seed, with the further hope that some may be led to grow the seedlings. When enough have learned to do this, the State Nursery will become unnecessary.

STOCK FEEDING

The relative feeding values of two rations of equal balance. What differences in production may be expected when rations are fed containing the same amounts of digestible nutrients yet made up largely of different materials?

This matter was under survey during three years, 34 cows being used. The first two years the rations were of medium balance, being rarely wider than 1:7 or narrower than 1:6. The third year two sets of rations were used, one with a nutritive ratio approximating 1:6, the other, 1:8.9.

The outcome of three years' trials seems to indicate that equivalent production is not of necessity to be expected when cows eat equivalent amounts of digestible nutrients derived from diverse sources.

The relative feeding values of "medium" and "wide" rations. This matter was under survey for three seasons. The results when grain was fed in equivalent amounts were essentially as follows: From 6 to 11% increase in production followed the substitution of a cottonseed-linseed ration in place of a corn and bran ration, the nutritive ratios averaging 1:1.6 and 1:1.10. The next year the producing power of a unit of dry matter was found to be 7% greater when the narrower ration was fed, a cottonseed-linseed ration being fed against Quaker oat ration, with nutritive ratios averaging 1:5.8 and 1:9. The third year, a repetition of the former year's trial, showed a 2% gain per unit of dry matter on the narrower ration, nutritive ratios being 1:5.3 and 1:5.7. The quality of the milk remained unchanged in all cases.

When the balance of the ration was varied by changing the amount of grain fed, the following results were obtained: When 3 pounds bran, 2 pounds corn meal, 1½ pound each of cottonseed and linseed meals were fed daily as compared with 2 pounds of bran and 1 pound of corn meal daily, the rations showing nutritive ratios as 1:5.9 and 1:11.8 "production paralleled feeding. Lessening or increasing the dry matter one-fourth respectively lowered or bettered production one-fourth. The milk was slightly poorer on the wider and scantier fed ration."

The second year's trial when five cows were used, fed 8 pounds of Buffalo gluten food against 2 pounds corn meal, 1 pound bran (nutritive ratios 1:5.5 and 1:9.5), a unit of dry matter contained in the "medium" ration made 5% more milk than did one in the wide ration. Less but better milk seems to have been produced by the scant ration.

In an earlier trial, using five cows during a winter's feeding, no relationship whatsoever was traced between changing nutritive ratios of the several rations and the products made coincident with such changes; that is to say an attempt was made to trace connection between increased protein eaten and gain in milk flow, but without success. Furthermore no connection could be traced between varying protein contents of the food and the casein content of the milk.

Feeding tests with corn by-products. The summarized statement as to several trials with over 60 cows, some loosely, some closely controlled, reads as follows:

1. *Cream gluten meal*, *King gluten meal* and *Buffalo gluten feed* were found to possess considerably greater feeding values pound for pound than has equal parts of corn meal and bran, while corn germ feed has about the same feeding value, and Chicago maize feed has little greater feeding value than has the corn meal and bran.

2. The feeding of these by-products seems to produce a slightly richer milk, one in which the fat is disproportionately increased. The change, however, is not sufficiently marked to be of practical importance.

Corn oil cake was fed to 6 cows as against corn and bran for 20 weeks. A pound of dry matter in the former produced a twelfth more yield than did a similar amount in the latter ration.

Germ oil meal was fed to 8 cows for 6½ months as compared with cottonseed and linseed meals and with bran and oats. The germ oil meal ration made 3% greater product than did the cottonseed-linseed and 6% more than did the ground oats ration. The quality of the milk remained unaltered. It carried much less digestible protein than did the cottonseed-linseed and one-fourth more than did the ground oats ration. The greater manurial value of the cottonseed-linseed ration gave it a slight advantage over its competitor. The germ oil meal ration proved superior to that containing ground oats to the extent of 1.50 cents daily for each cow.

Two lots of a gluten meal of the same make, one carrying 29, the other 36% protein, were fed in competition to four cows for nearly four months to determine whether the cow would confirm the chemist's findings and yield less when fed the poorer meal. She did not, since as much and as good milk was made on the one ration as on the other. The cows doubtless got enough to eat in either case.

The feeding value of distillers' dried grains. These were fed in two different seasons. Fed to six cows for 20 weeks against a mixture of equal parts by weight of corn meal and bran, it produced per pound of dry matter an eighth more milk and a sixth more fat. It was fed to 16 cows for nearly six months. Fed clear and undiluted it made 4% less milk of unchanged quality than did a ration one-third of which was wheat bran and two-thirds distillers' grains. The latter made a financial gain of three-quarters of a cent daily per cow over the clear grains ration. The cows rarely ate more than 7 pounds in 8 of the clear grains. Compared with brewers' dried grains it made 5 to 8% more milk and butter, but, owing to the low cost of the brewers' grains, the latter proved the more economical. Distillers' dried grains and cottonseed-linseed meals provèd équally efficient, but the latter was the more economical ration. Distillers' dried rye grains made less milk and butter than did the alcohol grains, a result which was foreshadowed by their analyses.

The feeding value of brewers' dried grains. This material was fed during two seasons, the first year to a single cow as compared with cottonseed-linseed meals; the second year to five cows making the same comparison and to six cows in comparison with distillers' dried grains. When compared with cottonseed-linseed meals they proved essentially equivalent, but the low price then placed for the brewers' grains made them economically preferable to the cottonseed-linseed meals. The distillers' grains as compared with brewers' by-products made 5% more milk and butter. The latter were economically the better ration.

The feeding value of malt sprouts. Six cows were fed malt sprouts for six months compared with cottonseed-linseed meals and with corn and oats. They were not relished. Some cows refused to eat them dry or soaked. When fed against cottonseed and linseed meals, dry matter consumption and milk yields dropped a tenth. When fed in comparison with ground oats, dry matter consumption dropped 9% and milk yields 4%. The quality of the milk was unchanged. The production to a unit of dry matter was the same on the sprouts ration as on the cottonseed-linseed one and 5% greater than on the oats ration. The cottonseed-linseed ration proved more economical than did the malt sprouts, the daily net gain per cow being 1.93 cents, half in extra butter and half in extra skimmilk and manurial constituents. The extreme high cost of oats made the financial showing unfavorable to that ration.

The feeding value of buckwheat middlings. Ten cows were used during two seasons.

Quantity. When 4 pounds buckwheat middlings replaced 1 pound corn meal and 1½ pounds each of cottonseed and linseed meals, production dropped about 3%; when it replaced corn meal, the production gained about 4%. The results the second year were more pronounced. A buckwheat middlings ration seemed fully equal to a cottonseed-linseed ration and carried a shade more digestible protein. It made from 8 to 11% greater product than did the ration of half corn and half bran.

Quality. Whenever fed, the quality of the milk was improved nearly 0.20%. This disproportionate increase in the fat content was observed both years. Buckwheat middlings fed in considerable quantities tends slightly to increase the fat percentage of milk.

Financial considerations. Buckwheat middlings made cheaper milk and butter than did the cottonseed-linseed or the corn and bran rations. The quality of the butter seemed somewhat impaired when they were fed in large quantities. Buckwheat middlings are highly variable in composition, as more or less of the hulls are included.

The feeding value of India wheat meal. India wheat, a plant of the buckwheat family, is grown largely in Vermont hill towns, the meal being used in lieu of buckwheat flour and as a cattle food. It rarely enters into trade. It was fed daily two seasons in comparison with wheat bran and with half and half cottonseed and linseed meals, to 12 cows the first and 11 cows the second year. Used in medium to small amounts, it seemed a fair substitute, pound for pound, of wheat bran, and nearly so of a mixture of equal parts of cottonseed and linseed meals; an outcome which its analysis would not have led one to expect but which is confirmed by the concordant results of the two seasons' trials.

Feeding values of cottonseed and linseed meals. Twenty cows were fed for nearly six months. Cottonseed meal seemed to possess a small though measurable advantage over linseed meal as a milk and butter making by-product; and since it cost less and carried a greater plant food content, it proved economically preferable.

Feeding value of so-called "cottonseed bran." Four cows fed 20 weeks. A pound of dry matter in cottonseed bran produced less milk and butter than did a similar amount in corn meal and bran, but on the basis of digestible dry matter was perhaps superior.

The feeding value of hominy feed. This breakfast food residue was fed daily two successive years, each year as compared with bran and with half and half cottonseed-linseed meals and the first year also as compared with gluten meal, 16 cows being employed the first and 11 the second year. It proved equal to average wheat bran as a milk maker and to be superior to a rather inferior grade thereof; but it was not the equivalent of either gluten meal or the cottonseed-linseed ration; neither was it as economical a concentrate as were these.

"Nutrene dairy feed," one of the first of the molasses feeds, fed to eight cows, was refused by seven.

Oat feed, fed for a month, seemed to have a value just about that of equal parts of bran and corn meal.

The feeding value of dried molasses beet pulp. This material, a residue from diffusion batteries of beet sugar factories mixed with residuum molasses, was fed for six months to six cows in comparison with wheat bran, and to five cows in comparison with silage. Pound for pound of dry matter it seemed essentially equivalent in feeding value to wheat bran and mature corn silage. At $12 a ton it was well worth trying; at $20, it was too costly to merit use.

"Nutriotone." A test of the effects of "Nutriotone," a condimental food, carried out by a former station officer, showed no beneficial results on the milk flow.

Heavy grain feeding. An increasingly heavy grain ration was fed to three cows. It began at 6 pounds and reached 12 to 14 pounds daily. The nutritive ratios ranged from 1:5.6 to 1:7.9 with 2 cows, and from 1:3 to 1:6 with the other. One cow maintained the flow and its quality for 24 days; another "responded to every additional pound of meal with an increased milk yield of better quality." Both shrank when put for 15 days on nearly equivalent amounts of a wider grain ration. When placed on another ration of equal weight but narrower ratio, one held her own, the other continued to decrease in yield. A farrow cow fed equal weights of bran and cottonseed meal, beginning with 6 pounds daily and increasing to 12 pounds, slightly bettered her flow. On 10 pounds bran and gluten feed she bettered it yet more; and on 10 pounds clear bran she lowered it. No unfavorable effects on cow or product resulted during the two months' trial.

Light and heavy meal feeding. Eleven cows were fed, some a grain ration with bran as a main constituent, others a grain ration made up of corn, cottonseed and linseed meals. The results were held to justify the statements that light feeds such as bran are often as good, weight for weight, as heavier meals, and that milk from bran fed cows creams less thoroughly by deep setting than does milk made by cows fed heavier meals.

Grain feeding at pasture. The records of 20 Franklin County herds fed little or no grain compared with those of 6 station cows fed grain, hay and silage, before, during and after the pasture season, indicate that full grain feeding at the barn and while the cows are on pasture, produces a much larger spring flow and maintains it considerably later in the fall. No attempt was made to learn whether the procedure paid.

Summer dairying vs. all the year dairying. The average records of about 10,000 Franklin County cows in 1892 were compared with those of the station herd. The former were summer cows, the latter calved at all times in the year. 4.11% fat is deemed the average for Vermont cows as a whole. The average fat percentage in the station herd was relatively uniform month by month, being practically constant (4.21 to 4.53% extremes); that for the summer calving cows was less so (3.69 to 4.94% extremes).

How much grain can be fed with profit to cows? This matter was under review for five years as follows:

1900—11 cows fed 6½ months either 4, 8 or 12 pounds of grain daily.
1901—15 cows fed 6½ months either 4, 8 or 12 pounds of grain daily.
1902—24 cows fed 6 months either 4, 8 or 12 pounds of grain daily.
1903—12 cows fed 6 months either 2, 4 or 8 pounds of grain daily.
1904—14 cows fed 6 months either 2, 4 or 8 pounds of grain daily.

The impelling motives were: (1) Vermont's heavy feed bill, approximately $10 per capita; (2) the fact that the money paid for feed mostly flows westward; (3) the ill-advised purchase of carbohydrates in over-abundance and the under purchase of protein; (4) the wide divergence in practice both as to amounts and kinds of grain fed; (5) the almost absolute dearth of data experimentally obtained, touching the relationship between the amount of grain fed and profit. The work falls naturally into two divisions, i. e., comparisons of low, medium and heavy grain feeding; and very low, low and medium grain feeding. The mere summing up of these several experiments occupied several pages in the original reports. The salient features, however, may be expressed as follows:

Does it pay to feed as little as 2 pounds grain daily? When 2 pounds were fed instead of 4, 68 cents were lost in butter product (rating butter at 20 cents) for each dollar saved in feed bills. When 2 pounds were fed instead of 8, for each dollar saved in feed bills 59 cents were lost in butter product at 20 cents per pound. When, however, skimmilk, rated at 15 cents per hundred, and two-thirds of the manurial values of the feeds are included in the reckoning, the outcomes were more favorable to the more liberal feeding and the figures $1.24 and $1.15 were substituted for 68 and 59 cents. The outcome in a comparison of this kind is bound to be a fluctuating one, depending on changing prices for feeds. Thus in 1903, using bran and brewers' grains selling at less than $20, it paid to feed grain liberally; while in 1904, using higher cost concentrates, the immediate outcome favored a low ration. In the one year the extra cost of grain was more than met by increased income for butter when the grain ration was doubled; and three-fourths of its extra cost was thus met when it was quadrupled, and skimmilk and manurial values were so much added gain. In the other year no adequate return was obtained from a usage of grain in excess of 2 pounds daily, either in butter or in butter, skimmilk and manurial values combined, an issue which seems to uphold the contention of those who argue for a restricted grain ration.

Yet it is not only a matter of immediate returns. No one could see Atalanta, in good flesh December 5, but lean and gaunt May 27 after 25 weeks of 2 pounds daily of grain, with hay and immature silage; or view the sharp falls in milk yield which followed curtailment of grain, or the partial recovery which paralleled their restoral, without realizing the relationship between grain and milk. Success seems to have followed restricted grain feeding in these trials; yet, one may well doubt whether a stinted grain ration will prove in the long run as profitable with good cows as will a more liberal one. Its effect on the persistency of the milking habit needs must be unfortunate. One has but to scan the records of the lightly fed cows for the past two winters and to note their gaunt condition to feel doubtful of the wisdom of feeding such very low grain rations to good dairy cows.

Does it pay to feed a low grain ration (4 pounds daily)? The substitution of an 8 pound ration for a 4 pound one was followed by a daily gain of 0.56 cents per cow one year and of 0.08 cents another year and only 0.07 cents during a third season. At no time did the increase in butter pay for the extra grain; but every time the comparison has been made the total increase in immediate cash (butter money), pork (skimmilk), and plant food (the enriched manure), has more than equalled the additional outlay for grain. The margin, however, has twice been so small as to be hardly worth reckoning. Viewed simply from the standpoint of immediate gain or loss the wisdom of feeding the extra 4 pounds seems open to question.

Does it pay to feed a high grain ration (over 8 pounds daily)? No. The first year's trials showed a gain of 0.48 cents; the second, a loss of 1 cent, and the third, a loss of nearly a cent and two-thirds daily per cow, when 12 pounds of grain were fed instead of 8 pounds. If butter returns only are considered the losses are yet greater. Not only may money loss be anticipated, but bovine health may be shattered and future usefulness be impaired.

Twelve pounds is excessive and unwise; 10 pounds may rarely pay its cost over a lesser amount; two pounds is too little, even with a full amount of roughage; four pounds, when roughage is good and plentiful, is likely to yield net returns nearly equal to those afforded by an eight pound ration, and to prove the better if skimmilk and manurial values are disregarded; but its residual effect on after-production may be unsatisfactory. When all the different factors are taken into consideration, from 6 to 8 pounds daily seem most advisable.

In these trials the roughages were of the best and were freely fed. The cows, even on a low ration, had enough to eat. The outcome would have been less favorable to low feeding had it not been for this fact. In lack of plentiful roughage supplies grain rations need proportionate modification.

The feeding value of alfalfa meal. Nineteen cows were fed nearly six months in trials comparing alfalfa meal with wheat bran and with distillers' dried grains. The alfalfa meal ration made less milk and butter, carried less fertilizing value and was fed at a loss, as compared with wheat bran ration, the meal costing $27 and the wheat bran $18.50. Had each cost alike the former would still have been *outclassed*. An alfalfa meal ration made one-seventh less milk, *one-sixth* less butter and the ration containing it carried one-sixth *less plant food* value than did one containing distillers' dried grains. *It is utterly* outclassed, even at equal prices.

"Protena," a proprietary article the basis and principal constituent of which is alfalfa meal, made as much milk as did a mixture of wheat bran, cottonseed and linseed meals, but 7% less butter. The ration carried but four-fifths the plant food content of its competitor, and was outclassed when financially compared.

Alfalfa products can hardly be considered economical unless sold at $18 or less.

The feeding values of silage and of hay. Six cows were fed on rations, one of which included and the other excluded silage. Seven percent less milk and butter were made when silage was omitted from the ration than when it was included. The quality of the milk remained unchanged. Rating hay at $10 a ton and silage at $3, there was a gain of 1⅗ cents daily per cow by replacing one-third of the hay by silage.

The feeding value of mixed silage of corn and soy beans. Four cows were fed for a month corn and soy bean silage in competition with corn silage. The addition of the soy beans neither bettered the silage appreciably nor augmented milk or butter yields.

The feeding value of a silage made from peas, vetch and oats. Six cows fed this silage while at pasture for six weeks made 6 pounds more butter than during the preceding six weeks on pasture supplemented by silage and fodder corn, and 32 pounds more than during the succeeding six weeks of barn life on corn and rye silages, which indicates that ensiled peas, vetch and oats may be as good as corn silage.

The feeding values of corn silage and of a silage made from soy beans and cow peas. Two cows, fed 12 weeks on corn silage and a silage of mixed cow peas and soy beans (which kept very poorly and was hardly richer in protein than was the straight corn silage), made less but better milk and essentially equal yields of solids and fat when somewhat more total dry matter in the mixed silage was fed. A hundred pounds of dry matter in corn silage proved superior to the same amount in the legume silage.

Relative values of corn silage and fresh fodder corn. Eleven cows, fed two weeks in early September on green fodder corn, shrunk 5% in butter yield. Nine cows during the same time, fed mature corn silage ensiled the previous year, gained 8%.

Feeding value of rye silage. Twelve cows were fed rye silage or corn silage during eight weeks. The rye silage was dryer, less readily eaten, and made 10% less milk and butter. Four cows passing from corn to rye silage, the latter fed four weeks later than the former, shrank 20%; three cows passing from rye to corn silage, gained 2%. The cows lost flesh on rye silage.

The "Robertson mixture." Two feeding trials were made of the so-called "Robertson mixture" (corn, horse beans and sunflower heads ensiled). The first one was made of little value by the slaughter of the herd because of tuberculosis; the latter was made with 6 cows for 16 weeks, the mixture being fed in comparison with corn silage. The claim made for the mixture was that on account of the added protein and fat in the horse beans and sunflower heads, 2 pounds grain could be saved to each 50 pounds of the compound silage, a claim which was put to test.

The cows did not eat the Robertson silage as readily as that made from corn. A fifth less dry matter was eaten from the Robertson mixture ration than when corn silage was fed. Essentially the same amount from beets or carrots. Since the dry matter from silage gained slightly in weight on the mixture ration. In this test the claims made for the mixture seemed upheld; yet notwithstanding, the Station does not recommend it unqualifiedly, owing to the difficulty of growing satisfactory stands of the horse bean.

Feeding values of corn silage and of roots. Eight cows fed 16 weeks stated that a pound of dry matter gave essentially the same returns when silage was fed as when it was replaced by a similar amount from beets or carrots. Since the dry matter from silage is less digestible than that from beets or carrots, it follows that a pound of digestible dry matter from corn silage yielded better returns than a similar amount derived from the roots. Both beets and carrots cost more to grow and yield less per acre than corn, and, per pound of dry matter, they produce no more and no better milk than does corn silage.

A very brief trial comparing Robertson mixture and corn silage with these two roots was made the previous year. Results seemed essentially alike as between the two roughages. But little stress is laid upon the outcome.

Corn silage vs. potatoes. Six cows fed for 12 weeks either on silage or on potatoes. A hundred pounds, both of dry matter and digestible dry matter, in silage proved superior to similar amounts in potatoes. The latter were eaten even more freely than was the silage, yet produced neither more nor better milk. At 15 cents a bushel they were more costly food for stock than was silage. The effect upon the quality of the butter was unfavorable.

Feeding value of pumpkins. Three cows were fed under conditions where pumpkins, seeds and all, were substituted for silage, about

2½ pounds of pumpkins being fed in place of 1 pound of silage. Practically the same production, but 5% more to the unit of dry matter was made on pumpkin feeding than on the silage ration. The quality of the milk remained unchanged.

In a second year's trials pumpkins were compared with hay and apple pomace, four cows being fed. The pumpkins when added to a hay ration, increased the milk flow 6%. The cows seemed in no way harmed nor was the butter injured. Pumpkins can serve only as a fall or early winter feed. Their equivalence to silage is in the proportion of 2½ tons to 1.

The feeding value of apples. Four cows were fed in alternate periods rations where apples replaced three-fourths of the silage. 8% less product was made on the apple than on the silage ration. The former contained, however, 8% less food; hence the unit of dry matter made as much on one ration as on the other. The quality of the milk was not altered. Pound for pound, apples did not prove equal to silage. Pound for pound of dry matter, they appeared to be nearly as useful. Apparently they have about 40% the feeding value of silage. No damage resulted to the cows from somewhat liberal feeding.

The feeding value of apple pomace has been under survey for many years. It has been fed freely in the fall to scores of station cows—both experimentally and as a staple food—with uniformly good results. Some of the concrete results may be stated as follows:

1889. Well relished when ensiled and apparently equivalent in feeding value to corn silage.

1901. From 3 to 4% more product was made on a pomace ration than on a silage ration.

1902. Seven percent more product was made on a pomace ration than on a silage ration.

1903. Practically the same production to the unit of dry matter was made on each ration.

At no time was the quality of the milk affected. Neither milk nor butter are injured by liberal feeding. Apple pomace needs no special care in ensiling. If leveled from time to time as put into the silo and left to itself uncovered and unweighted, it does well. It may be fed directly without being put in the silo.

The financial side of the proposition is most alluring. "Pomace at a dollar a ton at the barn is a great bargain and at a much higher cost is a fair equivalent of corn silage." A ton brings onto the farm 6 pounds nitrogen, 5 pounds potash and 2 pounds phosphoric acid worth, doubtless, well nigh a dollar as plant food. "It should be fed lightly at first until the cows get accustomed to it; then as high as 35 pounds daily may be fed without harming the cow or depleting the pocket book."

Effect of grooming of cows upon the milk flow. Eight cows in two seasons were uniformly fed, but were either groomed or left ungroomed in alternating periods. The first year no appreciable effect was observed; the second year, 4% less milk was made when the cows were groomed. The quality of the milk was unchanged. Grooming cows should tend to better the keeping quality of milk and the grade of the butter, but does not seem to add to the milk flow or its fat content.

Relation between water consumption by cows and barn and water temperatures. Water below 40° F. was drunk as freely as that which was warmer. Less water was drunk when the barn temperature was about 50° F. than when either higher or lower. Two cows during one winter.

Watering cows at will and at stated intervals. Eight cows for two seasons were uniformly fed and handled save that in alternating periods they were given water either twice a day or were allowed to drink at will, water standing in the stanchion. No change in quantity or quality of milk resulted.

Warming water for cows. Nine cows during two seasons were given in alternating periods water either warmed or cold. In the first year's trials the temperatures were 45° F. and 70° F.; in the second, 35° F. and 80° F.; otherwise their treatment was uniform. In neither case did appreciable differences occur in quantity or quality of milk. A net loss of 14 cents in 90 days occurred the second year over and above the expense of warming the water. The cows were amply fed and stabled in a barn the temperature of which was usually between 40 and 50° F.

Pig feeding. The experimental feeding of swine was pursued for 8 years. The salient results may be stated as follows:

In a trial of 2 Chester Whites, 2 small Yorkshires and 2 Berkshires, fed from ages of 5 weeks to 6½ to 7½ months, but little difference was observed justly to be ascribed to breed. What difference there was favored the Chester Whites. In a second trial of Poland Chinas, large and small Yorkshires, and Chester Whites, the latter "grew the fastest," but, with the first named "required the least food," while the "large Yorkshire made a pound of pork with the least cost of food." In a third trial Poland Chinas and Berkshires were equally successful; and in a fourth Berkshires outstripped Yorkshires.

The pigs in two years' trials averaged to use 1.43 pounds dry matter in food to make a pound of growth up to the time they weighed B. 10 (1890); 4:114-128 (1891); *J. L. H.* 8:86-92 (1894) (out of print). 53 pounds. This amount increased steadily as the pigs grew, until when they weighed 201 pounds it required 3.84 pounds of dry matter in the food to produce a pound of growth. Nearly all ceased to yield a profit after they reached about 180 pounds live weight.

The value of skimmilk in different trials ranged from 24 cents to 27 cents per hundred, averaging 25 cents. The manurial values averaged 61.5% of the food cost. Sour (thoroughly loppered) skimmilk produced just as good or a shade better results, pound for pound, as did sweet skimmilk. Two ounces of corn meal to each quart of skimmilk made a pound of pork at the least cost for food. Larger amounts of corn meal produced more rapid growth, but at an increased cost for food per pound of pork. A method of feeding early in life which tends to develop bone, muscle and digestive organs, rather than to form fat, builds a foundation on which greater profit may be made when heavy feeding begins in preparation for market. During the finishing off process 12 quarts of skimmilk daily per pig, with all the corn meal that would be eaten, produced a more rapid growth at less cost per pound than did 6 quarts of skimmilk under similar conditions.

It is usually stated that bulky or watery foods tend to promote stomachic and intestinal growth and to increase the shrinkage. Yet in a series of tests the shrinkage of pigs fed bulky foods was little if any greater than that of pigs fed more concentrated rations, while the shrinkage on watery and on concentrated rations were identical.

To the query whether it is "more profitable to feed skimmilk freely or to feed less, making up the shortage in grain"— or in other words, the relative economy of diluted or concentrated rations—the answers given were: "No marked effect one way or another"; and "the cost of food per pound increase and the profit slightly favored the less watery ration."

The relative feeding values of skim and butter milks are stated in one case to be as 5:4 and in another as equivalent.

The relative feeding values of corn meal and whole corn were twice determined with results "slightly" in one case and considerably in the other in favor of the meal. Doubt was expressed "whether the gain was equal to the cost of grinding." Feeding meal wet gave better results than feeding it dry.

Whey fed freely with bran proved more economical than did skimmilk freely fed with corn meal, but not more so than did smaller quantities of skimmilk fed with meal.

With pork at 4½ cents dressed weight, skimmilk fed freely was worth 12 cents, fed sparingly 18 cents, while whey was worth 11 cents per hundred, these figures being predicated on a calculation which subtracts grain cost from total receipts and allows manure to offset care.

Beekeeping. Trials made during three seasons were held to warrant the following statements:

1. No perceptible difference was noted between different sized frames in wintering or building up in the spring.

2. Double brood chambers for wintering and spring building up did not prove useful.

3. Stimulative spring feeding proved injurious.

4. Bees will make use of scrap wax in comb construction during the honey flow.

5. The Langdon non-swarmer proved a failure.

6. The periodical removal of all drones and drone brood failed to prevent swarming.

7. The removal of the queens during honey flow was of no avail.

8. No difference could be detected by experts in the quality of honey produced under otherwise similar conditions upon different comb foundations. The Weed new process foundation was thought superior.

9. The honey made by bees fed with cane sugar syrup did not differ materially in composition from that directly adulterated. Such as was made when the bees were fed but 20 pounds a week was somewhat more like normal honey than that made when they took 20 pounds a day. In each case some laevulose (honey sugar) was formed and a trace of acid added.

10. Feeding back extracted honey for section-filling did not succeed well.

11. Tests made seem to indicate that the winter temperature of the hives may vary without detriment to the bees.

DAIRY HUSBANDRY

Variations in milk. Data dealing with milk variations have been often published. They may be summarized as follows:

Over 400 cows on early pasture May 6-June 6, gave milk with highest and lowest fat percentages (daily samples) as follows: 3.63 and 4.03. A herd of 13 cows during the same time varied from 3.63

to 4.62%; on successive days, 3.75 and 4.29%, 3.88 and 4.62% were noted.

Monthly variations during a lactation period. A study of 16 lactations prompted the following statement:

1. All cows shrink in milk flow as the lactation period advances. If farrow, almost no change in quality ensues from calving to drying off, provided they remain farrow. If in calf, the milk increases in quality as it decreased in quantity. This increase is very slight for six months, but becomes pronounced just before drying off.

2. Cows calving in the spring give more milk for 3 months after calving than those calving in the fall. This situation is reversed from the 7th to 9th months. Fall cows show smaller variations in milk flow than cows calving in the spring.

3. For a few weeks after calving, milk is very variable in quality, being usually thinnest just after calving and slightly richer during the next two weeks.

A review of 108 lactations led to statements as follows:

Quality. The spring cow rapidly increases the fat content of her milk, beginning about five months after calving; the summer cow starts in about the third month, while the fall cow maintains fairly even quality throughout lactation, seldom improving it more than 0.5%. The solids-not-fat content is most uniform month by month in the fall cow's milk, that of the milk of spring cows lessening somewhat in the summer time.

Quantity. The fall cow "held out" better than the spring cow, and as a rule gave larger yields.

Extreme variations in quality during lactation. The greatest variation in the milk of 115 cows was 3.06% fat; the least, 0.33%; the average, 1.26%. The average variation of spring cows was 1.62% fat; of fall cows, 1.08%; of summer cows, 1.25%. The thinnest milk was given from the 2nd to 4th month of lactation, the richest after the 7th or 8th. Just after calving the milk is thinner in fat and in solids-not-fat than just before the cow went dry. The average, greatest, and least changes were respectively for fat and for solids-not-fat 1.13, 2.35 and 0.49%; 0.47, 1.94, 0.42%.

Variations from year to year. Most cows give about the same quality of milk year after year, beginning at the first calving. There is no general tendency for it to become either richer or poorer as the cow grows older. From one calving to the next cows may vary its quality perhaps 0.15% and rarely more than 0.25% fat. But 6 of 43 cows changed the fat content 10% in successive years.

The effect of age on the yield and quality of milk. The year records of 99 cows, comprising 427 years of bovine life, were studied to note the effect of advancing age upon milk yield and quality.

1. *Milk flow.* At the outset and until seven years old the general trend was upwards. The eighth year flow tended to be lower than that of the seventh or ninth and to resemble that of the tenth year. No cause was found nor is stress laid upon this sag. From the ninth year onwards the trend was downward.

2. *Total solids.* In 32 cases the trend is downwards; in 3, upwards; in 10, level.

3. *Fat.* In 29 cases the trend is downwards; in 3, upwards; in 14, level.

4. *Solids-not-fat.* In 23 cases the trend is downwards; in 9, upwards; in 14, level.

A comparison of these results with those derived elsewhere show lack of uniformity. The downward quality trend is borne out in two other studies but is opposed by yet others. The differences, however, one year with another are in no case large. Heifers usually give nearly their lifetime average fat content in their first lactation. The effect of advancing years is not important until old age becomes imminent.

The quality of the milk of strippers. Stripper milk is richer in fat and solids-not-fat and of a higher specific gravity than the average of the milking period if the cow is in calf. If she goes dry when farrow or when but recently served, the quality is not usually enhanced.

Variations due to breeding. In several cases the fat content of a heifer's milk closely resembled that of their grade Jersey dams. The sire was from very rich milking stock. A heifer, whose dam was a grade Ayrshire, sired by this bull, gave milk a percent better than did her dam. One heifer gave poorer (—0.39%), another better (+0.51%) milk than their respective dams, their sires being unknown. Two Holstein heifers gave a little poorer milk than their dams. The statement is hazarded that "in a herd already giving a good quality of milk the farmer is confined to selection as his method of increasing the richness of milk, breeding being used to preserve what has been gained by care, feed and selection."

The change from barn to pasture. "The food, environment and mode of life of the pastured cow are utterly unlike those she encounters in the stable. So profound a change may well affect her milk flow. That she makes more milk when out of doors is well understood; but whether it is richer or poorer in fat is less certain."

This matter was under survey during eight seasons. Three quite distinct sets of results were obtained: (1) An immediate and decided improvement followed, in from two to four weeks, by a return to the pre-pasture quality; (2) a slower change with a tendency toward improvement; (3) no change in quality. Study of the weather conditions of the several years, and their comparison with the tabulated data was made without enlightenment. Neither could a relationship between the stages of lactation and quality changes be established. Just why the herd gave no better milk on pasture than in the barn in 1895, 1897 and 1898; and the reason why the cows gave better milk on pasture than they did in the barn in 1896 and from 1900 to 1902, are not understood; but the facts are beyond dispute.

However, it is clear at any rate that no poorer milk results from pasture feeding, even when the flow is considerably augmented. At least as good or better milk, and more of it—and rarely a thinner milk, no matter how much more there is of it—is the general outcome. It shows how irrational is the state law which lowers the milk standard for May and June because of a supposed thinner milk made on pasture feeding.

The effect of fatigue on the milk flow. Three trials were made of the effect of fatigue on the milk flow, the cows being driven 10 to 12 miles and shipped 50 to 70 miles by rail. In the first trial with 25 cows, half gave richer milk the night of their arrival and all richer milk the next morning, than they did two weeks later, the fat being the most variable constituent. The quantity was unfavorably affected. In the second trial it was found that fatigue lessened the flow temporarily; affected its quality seriously for the first one or two milkings, and raised the quality after a little while. On the third trial six cows, 18 hours en route and not milked during this time, showed temporary enrichment of the milk for a day or two. Apparently there was no serious milk shrinkage. It seems safe to conclude as a result of the three trials that fatigue tends to lessen the flow temporarily, and variously to affect the quality for one or two milkings. The folly of testing milk before a cow has become accustomed to her new surroundings is clear.

Effect on milk flow of a change of quarters. The station herd, having been driven three and a half miles to a new barn, gave the two days following as compared with the two days before the change, 6.5% more milk solids. The general yield bettered, the general quality lowered.

The effect of abortion on the milk yield. Abortion in the station herd ceased after thorough disinfection with sulphur and plentiful injections of laudanum. There is no conclusive proof that this procedure led to the cessation of the disease.

Two different studies with 4 and with 6 cows led to the statement that abortion entailed: (a) A shrinkage of one-third in milk yield; (b) a gain of one-tenth in quality; (c) a shrinkage of nearly one-third in butter yield; (d) a more even quality of milk throughout the milking period.

The effect of weather on the milk flow. Trials designed to discover the effect of weather changes on the milk flow were made for three years. The first covered 30 herds from May 6th to June 6th, and four from June 7th to July 24th; the second covered the period from July 20th to September 15th, the station herd being used; a third covered the remainder of the pasture period, September 15th to early November, the station herd being used; and the last from February 25th to March 30th, using 7 cows stabled in a poorly constructed barn on a bleak hillside. The records of the 75 cows in the world's fair (1893) test were also used.

1. *Fall.* Nearly two-thirds of the changes in total solids percentages and over half those in fat were inverse to thermometric variations.

2. *Winter.* Nearly two-thirds of the changes in fat percentages were inverse to thermometric variations.

3. *Summer* (*soiling*) (world's fair). Over half the changes in total solids percentages and three-quarters of the changes in fat percentages were inverse to thermometric variations.

4. *Spring and summer* (*pasture*). 61% of the changes in the quality were in the opposite direction to changes in temperature.

5. *Summer* (*pasture*). 68% of the changes in total solids, and 54% of the changes in fat, were in the inverse direction to temperature changes.

6. These five tests, covering practically the entire year, and the conditions of pasture, summer soiling and winter barn feeding, point directly to the conclusion that the tendency of cows is to give from day to day richer milk when the temperature falls and poorer milk as it rises; or, in other words, the quality of the milk (solids and fat) tends to vary inversely to temperature changes.

Fast and slow milking. Eight cows milked slowly seemed to give as much and as good milk as when manipulations were rapidly done.

Milking two and three times daily. Two trials were made, using 2 cows, comparing diurnal with triurnal milkings (5 A. M. and 6 P. M.; 5 A. M., 1:30 and 8 P. M.) When milked thrice each cow gave the most and poorest milk in the morning, less of the richest milk at noon, and the least of a medium quality at night. The fat content only fluctuated, the several solids-not-fat remaining unaltered. The trials seemed to indicate that as a regular farm practice there is not enough to be gained from an extra milking to repay its cost. As a temporary means of increasing the flow it may prove of use.

A trial of the Hegelund or Danish method of milking. In 1895 four mature cows and three heifers were used in a trial of the Hegelund system, as well as of extra thorough stripping. The manipulations take from three to five minutes in each milking. The extra milk and butter obtained hardly repay the cost of extra labor of the Hegelund method; and the extra stripping, from which a return of 2¼ pounds of butter was gained, was done at a decided loss. If persistency of the milking habit and a more perfect udded development are encouraged, the adoption of the procedures has justification, particularly with heifers. This phase of the matter, however, was not studied. The additional load of dirt, dandruff, hair, dried manure, bacteria, etc., which fall into the milking pail because of the udder manipulation, is a distinct detriment, which, however, the use of a covered pail would tend to obviate. Incomplete milking causes large losses; but that any special virtue is possessed by a given set of manipulations over thorough stripping seem as yet unproven.

Cream raising by dilution—deep and shallow settings. In trials designed to determine whether successful gravity creaming could be secured without ice by the addition of hot or cold water, the following results were attained:

1. The usual method of deep cold setting did as effective work as any gravity creaming process and does not entail some of the disadvantages of other methods.
2. The addition of snow or pounded ice to the milk in the deep can caused good creaming, perhaps as effectual as by the usual method.
3. The direct heating of milk and setting at 58 to 60°, or its dilution with large bulks of cold water and setting at any degree, produced relatively poor creaming.
4. The heating and increased fluidity of milk caused by adding from a quarter to a third its bulk of hot water (130-150° F.), produced when set in water at 58-60° or shallow in cool air, as effectual creaming as did ordinary settings; but it entails increased tank room, thinner skimmilk and a rapidly souring cream.

5. There seemed little preference as to the use of hot or cold water or of none at all in deep air settings.

6. Nothing was gained by dilution, either hot or cold, in cool shallow setting.

7. Delays in settings and manipulations of the milk prior to setting seemed to affect the deep setting creaming more than shallow setting creaming.

Cream raising by dilution. Fresh cows' milk diluted with ¼ to ⅛ water at 130-135° F., creamed better by deep setting at 55-60° F. than did undiluted milk. No gain ensued by this treatment of stripper milk at 55° F., but at 60° F. gain ensued.

The addition of one-fifth part ice water to cold deep set milk was followed by poorer creaming and churning.

Dilution separators. Trials of the "Wheeler Gravity Cream Separator" (wherein it was advised to dilute milk with equal bulks of cold water, to allow it to stand two hours and to skim), indicated that the method was faulty in that from 13 to 40% of the total fat was lost.

Churning experiments. One hundred and twenty churnings afforded data held to warrant the following conclusions:

1. The percent of fat in the butter appears lessened by thinning the cream, by increased churning temperatures, by increased cream acidity, by lengthened time of churning, and by changing from a separator to a deep setting system. The fat percentages of sweet and sour cream butters were closely alike.

2. The percent of curd in butter did not seem affected by the length of time or the varying temperatures of churning. The sweet cream butters contained more curd than those made from sour cream; and the deep setting butters, more than did the separator made goods.

3. The churnings were most exhaustive with thick and ripened cream at low temperatures, while varying acidities, length of churning and methods of cream separation showed little effect.

4. The conditions most favorable in these trials to the exhaustive churning of a firm butter of high fat content appeared to be: (1) a thick cream containing 10 to 16% of the original milk; (2) ripened cream, unless churning at 54° or below; (3) a low churning temperature.

The effect of freezing milk on creaming and churning and upon the quality of the butter. A series of trials were made wherein milk was divided into two lots, one-half allowed to freeze and the other handled in the usual manner; then churned, the butter worked and scored.

Neither skimming, ripening nor churning appeared to be impaired. Not so, however, with the scoring. The average scores of two sets of 15 lots each were: frozen butter, 93.2; normal butter, 93.5. Freezing tended very slightly to lower the grade of the butter, yet freezing *per se* is not necessarily a menace to good butter-making. It should not be inferred, however, that infrequent creamery receipts, delivered more or less frost bitten, will make as good a butter as if they had been delivered unfrozen.

Mechanical losses in handling milk. BUTTER. More or less loss of the solid material ensues in handling milk for the making of butter. This is shown by the fact that the sum of the solid ingredients found in the products (butter, skim and buttermilks and slops) does not equal the amount in the whole milk used. This loss falls almost entirely on the fat. The casein and albumen, milk sugar, and ash in the products check fairly well with those in the original milk, but the fat does not. This loss of fat is inversely proportional to the amounts of milk used and to the care taken in its handling, decreasing relatively with increased volume of milk handled and with greater care. The loss is a purely mechanical one, due to the greater viscosity of cream as compared to skimmilk. If the cause were chemical or biological as great proportional destruction would ensue with large as with small lots of milk. The mechanical losses in 22 days' survey of the operation of a small creamery approximated 0.9%.

CHEESE. Three days' work at a cheese factory indicated that mechanical losses were less important than in butter making. The objects of the two processes are opposite. One makes a viscid product, butter, the other a less viscid one, cheese. The nature of the products and the method of handling them favors greater mechanical loss in butter making than in cheese making.

Aeration of milk. Milk was divided into three lots, one set in deep setting at once at 96° F.; another run over a Star aerator without cooling and set at 96°; another similarly aerated and cooled by the same operation and set at 49°. This operation was repeated nine times. Similarly three lots of milk were handled by the Wood aerator, which divides milk into streams instead of spreading it in sheets, the temperatures being 92°, 82° and 67° respectively. The completeness of creaming was impaired by cooling but not by aerating in the former case, while in the latter there was no effect one way or another. Milk aerated and cooled by the one operation kept sweet one-eighth longer than did that not thus handled. The keeping qualities of milk aerated in such a manner that its temperature was maintained was not enhanced.

Making cheese from different qualities of milk. Cheese was made of milks testing 3, 4 and 5% fat. The fat losses were nominal, ranging from 0.17 to 0.30% fat; 9, 10⅝ and 11½ pounds cheese were made per 100 pounds milk. The cheeses were rated at 7½, 8¼ and 8¼ cents. It is stated that milk containing much over 4% fat can be more profitably made into butter than into cheese; that milks carrying 3-4% fat, when paid for on the butter fat basis, are accorded a just return; that such payments are less exact for milks below 3 or above 5%; and that the maker's skill and market considerations are important factors.

Changes in the ripening of cheese. Tests of three days' makes indicated that during the first month the main changes were lost moisture, a possible mechanical loss of fat, and slight loss of casein. The cheeses were but slightly cured, and were very mild and moist. Hence this statement at most only indicates initial changes.

Paying for separator cream at the creamery—cream testing. Dairymen who sell hand separator cream to creameries often fail to receive their just dues, owing to faulty sampling, testing and accounting. Suggestions are made as to sampling methods. The moderate warming of the sample and the use of a fine sieve and pestle are urged as means of promoting thorough mixing and accurate analysis.

The absolute necessity of testing a full 18 grams of cream is emphasized. Weighing the cream into the test bottle is the only known means whereby accuracy may be attained. A study was made of a method of analyzing separator cream relatively rich in fat, which had temporary vogue in certain Vermont creameries, consisting of heating to temperatures of 140 to 150° F. prior to pipetting and the use of a correction factor. The results were unsatisfactory. About 80% of the results were concordant, but 60% of the richer creams showed wide divergences. Individual differences served to make correction factors unreliable when applied to rich cream.

A larger "surplus" is due to patrons who furnish cream than to those who deliver milk. A higher price per pound of butter or of butter fat is similarly their due. The extra "surplus" averages 3%; the extra price is usually close to a half cent. The reasons why cream patrons should be thus favored are discussed at length and examples cited. Several examples are given of the sundry methods of determining milk-fat and cream-fat surpluses, of calculating payments on the "butter basis" or on the "butter-fat basis," etc.

Tests of cows at state fairs—home vs. fair grounds. Trials of cows were made at the state fairs of 1889 and 1890, nine cows being entered in the first and six in the second test. The trials were 24 hours long. Milks were deep set, creams ripened 24 hours and churned at once. The milks were of course sampled and analyzed. In each case similar comparisons were made with the same cow at home under normal conditions amid familiar environments. The conclusions as to the validity of fair ground tests are stated as follows: The effect of worry and confusion on the milk flow is variable. Some cows made more at home, others seemed stimulated by excitement and nervousness, and made the better showing at the fair grounds. Nervous excitement tended, however, to lessen the quantity of milk ingredients and variously to affect quality. The true "butter test" of a cow can hardly be made at a great fair as well as at home.

A comparison of udder conformation and of milk production. Do cows with ill-shaped udders make less butter on that account? The mature cows in the station herd were carefully surveyed and grouped into three lots; those with well-balanced, those with fairly well-balanced, and those with ill-balanced udders. The result was not strongly indicative one way or the other, but tended to bear out score card findings. Four out of five cows with well-balanced udders made more butter than did the average of 18 carrying fairly well-balanced or 11 with poorly-balanced udders. They also made more than the 12 year herd average (324 pounds). Per contra, 8 out of 11 with poorly-balanced udders made less butter than did the average of the 5 whose udders were well built or of the 18 whose glands were fairly well formed; and their records were all below the 12 year average.

Forty-six percent of the milk solids and fat were produced from the fore quarters of 5 cows and 54% from the hind quarters.

A comparison of score card judgments and of milk and butter records. A comparison of the results of the scorings of registered and of high grade Jerseys and of registered Ayrshires in three different herds, with their production records for milk and butter. The milk and butter yields of 83 cows for periods of from 1 to 8 years were compared with scorings. Nineteen cows scored 90 and above, 20 scored 88 or 89 and 12, 87 or below. These groups averaged milk and butter yields in the order stated: 6478, 6263 and 5699 pounds of milk, and 321, 325 and 286 pounds of butter.

The high scoring show ring cows were really in the long run little if any better producers than their less well-equipped sisters. But, on the other hand, the relationship between lack of conformation to dairy types and lessened production was clearly shown. The "poor lookers" were poor yielders and the show ring verdict did them no injustice. But in awarding prizes to cows which are really inferior as producers to others which do not look quite as well, and consequently do not score as high, it does do injustice. The importance of attested milk and butter records is recognized by breeders' associations. Why not in the score card?

Bovine tuberculosis. The discovery of the serious infection of the station herd in January, 1894, led to its slaughter and to the publication of a bulletin, a summarized statement of which is appended. This bulletin, together with the action taken by the state cattle commissioners, predicated largely on the statements contained therein, led in the fall of 1894 to the first enactment in Vermont looking toward the control of the disease under state auspices, a policy which has continued to this day.

Tuberculosis was discovered in the station herd in January, 1894, by means of the tuberculin test. But two cows were out of condition, yet 24 animals reacted. The post-mortems confirmed the test. Two animals which did not react showed no disease upon slaughter. The distribution of the disease was: lungs 90%, udder and its glands 73%, intestines and mesenteric glands 50%. Physical examination alone did not detect disease in several cases. Six of the cattle were bought from (probably) infected herds. The barn was disinfected by burning sulphur and the use of corrosive sublimate

1. *Prevalence and history.* Tuberculosis is the general name for a class of diseases which attack various organs and which both man and animal readily contract. The human death rate from all forms of the disease is about one in four. Cattle are affected in various proportions in different parts of the world. The extent of bovine tuberculosis in this country cannot be accurately stated owing to the lack of systematic inspection. The disease has been known from antiquity

2. *Cause.* Its sole and exciting cause is a germ, *Bacillus tuberculosis*, a parasitic, microscopic, rod-shaped plant which lives in the animal body, has great vitality, resists heat, cold, moisture, drought, decay and often the process of digestion. It is killed by boiling, by long continued heat at from 150 to 170°, as well as by sunlight, air and certain chemicals. Infection occurs: (1) by breathing the germs; (2) by swallowing the germs; (3) by their entrance through a cut or wound. The main sources of infection are: (1) the dust of the dried spittle of consumptives, or other tuberculous matter either breathed or swallowed; (2) contact with tuberculous material or people; (3) the meat and milk of tuberculous animals.

3. *Accessory causes.* The *Bacillus tuberculosis* is the sole cause of the disease; but there are conditions so favorable to its development

that they are well termed accessory causes, although strictly speaking they are not causal. Among these conditions are: (1) hereditary predisposition; (2) unhealthy surroundings, poor ventilation, uncleanly, dark, damp, hot and cold stabling, lack of exercise, climatic influences; (3) faulty feeding, under-feeding, over-feeding, feeding on unwholesome or indigestible materials, over-production; (4) faulty breeding, in and in breeding, early, late and frequent breeding, intensive breeding, lack of constitution; (5) ill-health, temporary predisposition; (6) physical constitution.

4. *Symptoms.* The symptoms of bovine tuberculosis are more obscure than those of the human disease, and often baffle detection. Any attempt to describe them would probably prove misleading

5. *Lesions.* Wherever the germs locate in the body they irritate the tissue, forming round nodular masses. These newly formed tubercles are usually soft and red. In chronic cases they become cheesy, limy, and disintegrate and run together, forming yellowish, caseous, pus-containing masses of various sizes imbedded in the diseased organs. The lungs, linings of the chest and abdomen, the lymphatic glands and the bowels are most often diseased. Sometimes the tubercles are too small for the naked eye to see.

6. *The tuberculin test.* Tuberculin is made from pure cultures (growth separate from all other germs) of the tubercle bacillus, concentrated, sterilized (to kill all germ life) and filtered. It contains the chemical poisons created by the life functions of the germs. It is successfully used to detect tuberculosis in cattle. A small quantity injected into a tuberculous animal usually produces a fever; but if the animal is healthy and it is properly used there should be no rise of temperature. A rise of 2° F. above normal is ground for suspicion. The tuberculin test is fallible. Mistakes have been made in its use, and it has sometimes failed in careful hands. It is, however, much more reliable than any other known means of diagnosis. If properly made and used, it cannot cause tuberculosis.

8. *Prevention.* Both human and bovine tuberculosis are preventable, and the means which may be taken to prevent its spread are: (1) Official inspection of cattle, meat and milk; (2) the destruction or disinfection of human spittle; (3) careful disinfection of places occupied by tuberculous men or animals. The stock owner, so far as possible, should keep his cattle under healthy conditions, should keep each animal in its own stanchion, should isolate suspected animals, should buy cautiously, should exclude human and animal consumptives from the barn, should test all purchases, should kill and destroy diseased animals, disinfect the premises and test the rest of the herd.

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EXPERIMENT STATION

BURLINGTON, VT.

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Commercial Feeding Stuffs

The Viability of Weed Seeds in Feeding Stuffs

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Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 138: COMMERCIAL FEEDING STUFFS

THE VIABILITY OF WEED SEEDS IN FEEDING STUFFS

By J. L. Hills, C. H. Jones and C. L. Beach

Two hundred and one samples of feeds were drawn in the spring inspection of 1908. One-half of these represented seventy-seven brands of guarantied goods, (by-products of the oil mills, glucose and breakfast food factories, the distilleries and breweries, and sundry manufactured and special products) the remainder were wheat offals and provenders. One hundred and twelve were drawn in the winter inspection, two-thirds, representing guaranteed foods and a third provender and wheat offals. These samples were tested for protein only owing to lack of funds.

THE RESULTS OF INSPECTION

The results of inspection of the guarantied goods are displayed on pages 6-10. These tables show the manufacturer's name, brand name, protein guaranty and analysis of each goods, a statement of the number of inspections since 1899 in which each brand has been analyzed and the number of times it has and has not met the protein guaranty statement within one percent.

A few remarks touching the tabulated results seem in order.

SPRING INSPECTION

Eleven *cottonseed meals* made good their guaranties.

Four *linseed meals* were analyzed, three old process and one new process. Three made good their guaranties; one failed by 2½ percent.

Seven brands of *gluten feed* were found. One of these was unguarantied. Three (Buffalo, Pure, Pekin) met guaranty; three (Clinton, Cedar Rapids, Bay State) failed to meet guaranty by 4, 5½, and 3 percents respectively. The unguarantied goods (Tiger) was 2 per cent below the lowest guaranty of any other brand.

Three brands of *distillers' grains* were tested. One (Climax grains) met guaranty. Two (Empire State Dairy Feed, Biles XXXX) were respectively 2 and somewhat over 1 percent below guaranty. Three proprietary mixtures (Union, Paragon, Wirthmore) into which these good largely enter met guaranties.

Four brands of *brewer's grains* made good their guaranties.

One brand of *flax seed* proved nearly 2 percent below guaranty.

Six brands of *molasses feeds* were found. Four (Sucrene Dairy and Horse, Molac Dairy and Horse) met guaranties. The Daisy was found from 2½ to 4 percent below guaranty. The Prize contained barely half its guaranty, carrying only about 9 percent of protein where 18 was guarantied.

Ten *oat feeds* and *corn and oat feeds* were found. Eight (Schumaker, Quaker, Victor, Haskell, Brooks, Griswold and McKinnon Special, Xtra Good, Wirthmore) met guaranties. Two (Vim, Sterling) were 1½ percent and 1 percent below guaranty.

Three lots of *hominy feed* met guaranty.

Purina alfalfa meal was only one percent below guaranty. The Purina meal mash, and two Purina hen feeds met guaranties.

Sundry beef scraps, cracked bones, poultry feeds, etc., met guaranties save the following: Park and Pollard dry mash feed, 3½ percent below; Wirthmore Poultry Mash, 3 percent below.

Seventy-one samples of *wheat offals* (brans, middlings, mixed feeds) appeared to be of standard grade; although one sample of middlings carried as little as 14.6 percent protein and is a somewhat doubtful sample.

Fifteen *provenders*, local grindings, seemed to be of good grade.

WEED SEEDS

The following statements as to the weed seed contents of several of the samples of feeds *collected in March last* are commended to the attention of buyers:

*H. J. Flax feed.** Very many; bright and seemingly viable.

Sucrene Dairy feed.† A large number, apparently in good condition.

Sucrene Horse feed.† A very large number, apparently in good condition.

Prize Dairy feed. Quite a number and apparently in good condition.

Molac Dairy feed. A considerable number, apparently in good condition, in one sample; comparatively few in another.

Daisy Dairy feed. A considerable number, apparently in good condition in one sample; comparatively few in another.

Schumaker's Stock feed, Schumaker's calf feed, Sterling Stock feed, Ides' Ideal corn, barley and oat feed, and a single middlings, carried each a few.

WINTER INSPECTION

Eight brands of *cottonseed meal* were drawn. The following failed to meet guaranty: One lot of Hunter Bros. Milling Co's. (4 percent below); Purity (1.3 percent below); Buckeye (2.5 percent below). The Hunter and Buckeye shortages are in process of adjustment.

Two brands of *linseed meal,* one old, one new process, met guaranties. One lot of flax feed also made good.

Three out of four brands of *gluten feed* met guaranty; one (Cedar Rapids) was found 1.4 percent short.

Five brands of *distillers grains* were drawn. Three were found seriously deficient as follows: Empire State Dairy Feed, 3.5 percent; Biles XXXX, 2.5 percent; Climax Grains, 5.2 percent. It is a great pity that the manufacturers of so good a feed persist in either unduly inflating their guaranties or in deflating their goods.

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*The jobber of these goods claims that from the feed as now shipped the seeds have been eliminated.

†The Boston representative of the American Milling Co. assures the writer that measures have been taken which serve to eliminate weed seeds from Sucrene feeds as sold on Vermont markets from midsummer 1908 onwards.

Three brands of proprietory goods, Union Grains, Paragon and Unicorn, into the formulas of which distillers' grains largely enter, made good their protein promises.

Ten brands of *molasses feeds* were analyzed. The XXX feed made by the Milwaukee Grain and Feed Co., failed by 1.5 percent to meet its guaranty statement.

Four samples of *hominy feed,* two unguarantied, seemed to be of standard quality

Several samples of *provenders,* (local grindings), of *bran, middlings* and *mixed feed* seemed of standard grade. The Valley City Milling Co's. bran and cow feed (wheat offals) ran rather low in protein for this class of goods, carrying but 14.1 and 14.6 percent respectively.

SPRING INSPECTION

Manufacturer or Jobber.	Brand.	Protein.		No. of inspections.		
		Guar.	Anal.	Total.	Above guar.	Below guar.
COTTONSEED MEALS						
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41	40.5	17	15	2
F. W. Brodé Co., Memphis, Tenn.	Owl	41	40.9	16	15	1
J. Lindsey Wells Co., Memphis, Tenn.	Star	41	44.8	14	12	2
J. Lindsey Wells Co., Memphis, Tenn.	Sun	41	43.2			
Hunter Bros. Mill Co., St. Louis, Mo.	Prime	41	42.5	10	7	3
Hunter Bros. Mill Co., St. Louis, Mo.	Prime	38.5	41.9			
American Cotton Oil Co., New York, N. Y.	Choice	41	41.2	16	15	1
J T. Walker, Memphis, Tenn.	Purity	41	42.5			
T. H. Bunch, Little Rock, Ark.	Old Gold	41	42.1	2	2	0
Roberts Cotton Oil Co., Jonesboro, Ark.	Choice	41	44.5	2	2	0

LINSEED MEALS

American Linseed Oil Co., Chicago, Ill.	New Process	36	36.6	15	11	4
American Linseed Oil Co., Chicago, Ill.	Old Process	32	36.4	15	13	2
Metzger Seed and Oil Co., Toledo, O.	Old Process	30	35.5	9	8	1
Kellogg and Miller Co., Amsterdam, N. Y.		36.7	34.2	2	0	2

GLUTEN FEEDS

Corn Products Refining Co., Chicago, Ill.	Buffalo	23	24.6	17	10	7
Clinton Sugar Refining Co., Clinton, Ia.	Clinton	24	19.8	2	0	2
Corn Products Refining Co., New York	Pure	23	25.4			
J. E. Soper and Co., Boston, Mass.	Bay State	24	21.4	3	0	3
Glucose Sugar Refining Co., Chicago, Ill.	Pekin	24	26.5	9	4	5
Corn Products Refining Co., Chicago, Ill.	Tiger		21.1			
Douglass and Co., Cedar Rapids, Iowa	Cedar Rapids	24	18.4	6	2	4

DISTILLERS' DRIED GRAINS

J. D. Page and Co., Syracuse, N. Y.	Empire State	32	29.7	10	2	8
Deutsch and Sickert Co., Milwaukee, Wis.	Climax Grains	34	34.	3	1	2
J. W. Biles Co., Cincinnati, O.	XXXX	33	31.8	7	2	5
J. W. Biles Co., Cincinnati, O.	Union Grains	24	23.8	6	6	0
St. Albans Grain Co., St. Albans, Vt.	Paragon Dairy	28	33			
St. Albans Grain Co., St. Albans, Vt.	Wirthmore Dairy	24	28.5			

BREWERS' DRIED GRAINS

Anheuser Busch Brewing Asso., St. Louis, Mo.		24	25.	4	4	0
Jos. Schlitz Brewing Co., Milwaukee, Wis.		24.5	31.3	2	2	0
W. J. Lemp Brewing Co., St. Louis, Mo.	Holstein	27	28.1			
	Owl	26	30.5			

FLAX FEED

Henry Jennings, Boston, Mass.	H. J.	17.34	15.6	2	0	2

MOLASSES FEEDS

American Milling Co., Chicago, Ill.	Sucrene Dairy	16.5	17.8	7	7	0
American Milling Co., Chicago, Ill.	Sucrene Horse	13.5	13.1	6	5	1
Quaker Oat Co., Chicago, Ill.	Molac Dairy	15.5	15.7	5	5	0
Quaker Oat Co., Chicago, Ill.	Molac Horse	11	11.3	4	4	0
Milwaukee Molasses Feed Co., Milwaukee, Wis	Prize Dairy	18	9.4	3	1	2
Great Western Cereal Co., Chicago, Ill.	Daisy Dairy	16	12.9	2	0	2

OAT FEEDS; CORN AND OAT FEEDS

Quaker Oat Co., Chicago, Ill.	Schumaker Stock	10	10.9			
Quaker Oat Co., Chicago, Ill.	Quaker Dairy	12	14.3			
Quaker Oat Co., Chicago, Ill.	Vim	7.5	5.9			
Quaker Oat Co., Chicago, Ill.	Victor	7.5	8.0			
Great Western Cereal Co., Chicago, Ill.	Sterl'ng	11	9.7	2	1	1
W. H. Haskell and Co., Toledo, O.	Stock	8	8.8			
A. H. McLeod Mill Co., St. Johnsbury, Vt.	Brooks	7.63	7.9			
Griswold and McKinnon, St. Johnsbury, Vt.	Special	7.63	8.3			
Griswold and McKinnon, St. Johnsbury, Vt.	Xtra Good	7.63	8.3			
E. T. & H. K. Ide, St. Johnsbury, Vt.	Ideal	9	7.1			
St. Albans Grain Co., St. Albans, Vt.	Wirthmore	10	10.3			

ALFALFA MEAL

Purina Milling Co., St. Louis, Mo..	Purina	16	15.1	4	1	3
Ralston Co., St. Louis, Mo.........	Colorado		14.5			

HOMINY FEED

Chapin and Co., Boston, Mass.....	Niagara	10	9.3			
Chas. M. Cox Co., Boston........	Wirthmore	9.5	9.3			
Chas. M. Cox Co., Boston	K. D. Yellow	10	10.5			

POULTRY FEEDS, ETC.

Husted Milling Co., Buffalo, N. Y..	Laying Mash	15	15.8			
Husted Milling Co Buffalo, N. Y..	Poultry Food	12	14			
Husted Milling Co., Buffalo, N. Y..	Forcing Mash	19	18.7			
Purina Mills, St. Louis, Mo........	Prime Mill feed	17	17.3	2	2	0
Purina Mills, St. Louis, Mo........	Mill feed (Scratch)	11	11.2			
Purina Mills, St. Louis, Mo........	Mill feed (Chicks)	11	11.4			
Park and Pollard Co., Boston, Mass.		23	19.5			
Park and Pollard Co., Boston, Mass.	Growing feed	14	14.3			
Chas. M. Cox Co., Boston, Mass....	Wirthmore gritless	9	11.2			
Chas. M. Cox Co., Boston, Mass....	Wirthmore poultry mash	20	16.7			
Chas. M. Cox Co., Boston, Mass....	Scratch feed	10	9.9			
C. S. Page, Hyde Park, Vt.........	Perfected	24	26.3			
Swift's Lowell Fertilizer Co., Boston, Mass.	Edible bone meal	10	24.2			
Beach Soap Co., Lawrence, Mass...	Star cracked bone	25	26.3			
Beach Soap Co., Lawrence, Mass...	Meat and bone meal	30	35.3			
Burlington Rendering Co., Burlington, Vt.	Beef scraps	40	44.9			

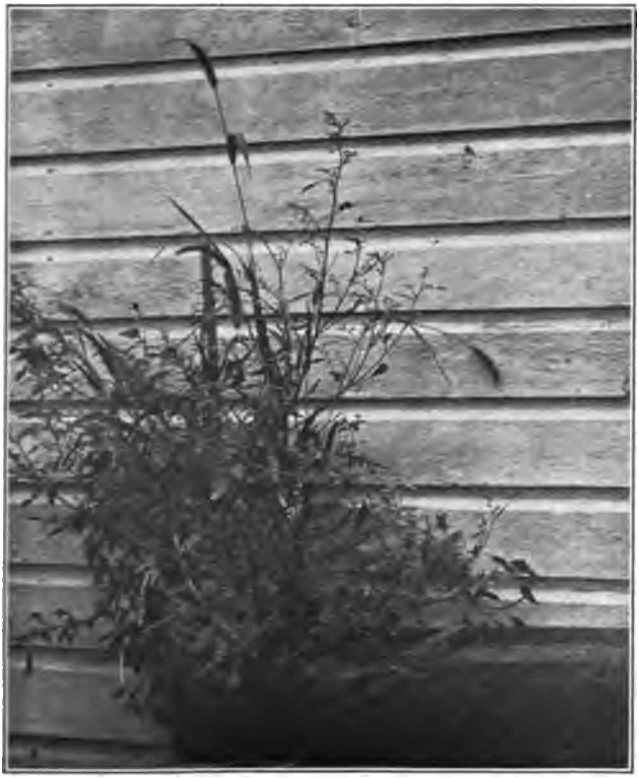
MISCELLANY

Blatchford's Calf Meal Factory, Waukegan, Me.	Calf meal	25	28			
Quaker Oat Co., Chicago, Ill......	Schumak'r calf meal	19	21.1			

WINTER INSPECTION

MANUFACTURER.	JOBBER.	BRAND.	Guar.	Anal.
COTTONSEED MEALS				
Humphreys, Godwin & Co., Memphis, Tenn.		Dixie,	41	40.8
Humphreys, Godwin & Co., Memphis, Tenn.		"	41	41.6
Humphreys, Godwin & Co., Memphis, Tenn.		"	41	43.
F. W. Brodé Co., Memphis, Tenn.		Owl,	41	41.3
F. W. Brodé Co., Memphis, Tenn.		"	41	41.2
Hunter Bros. Milling Co., St. Louis, Mo.		Prime,	41	41.4
Hunter Bros. Milling Co., St. Louis, Mo.		"	41	37.
T. H. Bunch Co., Little Rock, Ark.		Old Gold,	41	40.4
Blackstone Smith, New Orleans, La.		Purity,	41	39.7
Chapin & Co., Boston, Mass.		G. Diamond,	41	42.5
American Brokerage Co.		Eagle,	41	41.
Buckeye Cotton Oil Co., Greenwood, Miss.		Buckeye,	39	36.4
LINSEED MEALS				
American Linseed Oil Co., Chicago, Ill.		New Process,	36	36.
American Linseed Oil Co., Chicago, Ill.		Old Process,	32	35.2
GLUTEN FEEDS				
Corn Products Ref. Co., Chicago, Ill.		Buffalo,	23	25.4
Clinton Sugar Ref. Co., Clinton, Iowa		Clinton,	23	23.7
Western Glucose Co.		Western,	23	22.6
Douglas & Co., Cedar Rapids, Iowa		Cedar Rap's,	24	22.6
DISTILLERS' DRIED GRAINS, ETC.				
J. D. Page & Co., Syracuse, N. Y.		Emp. State,	32	28.5
J. W. Biles Co., Cincinnati, Ohio		XXXX,	33	30.5
Deutsch & Sickert Co., Milwaukee, Wis.		Climax Gr's,	34	28.8
Ajax Mill and Feed Co., New York		Ajax Flakes,	31	31.6
St. Albans Grain Co., St. Albans, Vt.		Paragon Dairy Feed,	28	28.5
J. W. Biles Co., Cincinnati, Ohio		Union Grains,	24	24.6
Ajax Mill and Feed Co., New York		Unicorn Dairy Ration,	26	26.5
FLAX FEED				
Henry Jennings, Boston, Mass.		H. J.,	16	15.6
MOLASSES FEEDS				
American Milling Co., Chicago, Ill.		Suc. Dairy,	16.5	18.9
American Milling Co., Chicago, Ill.		" "	15	19.8
American Milling Co., Chicago, Ill.		Suc. Horse,	10	9.9
American Milling Co., Chicago, Ill.		" "	13.5	14.
Sugarine Co., Chicago, Ill.		Sugarine,	16.5	18.4
The Northwest Milling Co.		Sugarota,	18	18.9
International Sugar Feed Co.		International,	15.1	18.9
Milwaukee Grain and Feed Co., Milwaukee, Wis.		XXX,	17.5	16.
Great West Cereal Co.		Daisy,	14	15.8
Northwestern Milling Co.		Comet (XXX)	10.3	19.
OAT FEEDS				
Quaker Oat Co., Chicago, Ill.		Schumaker Stock Feed,	10	11.2

THE VIABILITY OF WEED SEEDS IN MANURE



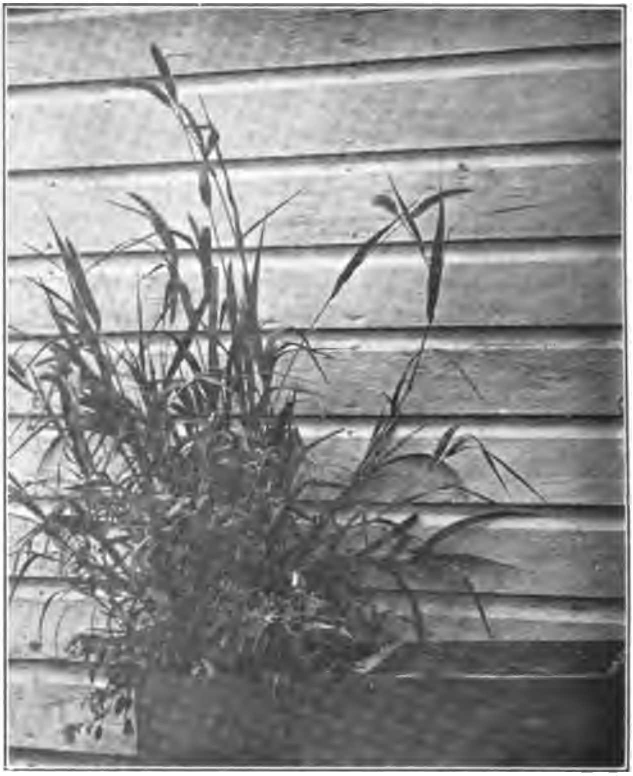
When the cow was fed the feed containing weed seeds (April 26).

When she was not thus fed (April 16).

"Look here, upon this picture, and on this."

Hamlet, III. 4.

THE VIABILITY OF WEED SEEDS IN MANURE



When the cow was fed the feed containing weed seeds (April 27).

When she was not thus fed (April 17).

"Comparisons are odorous."

***Much Ado About Nothing*, III. 5.**

THE VIABILITY OF WEED SEEDS IN MANURE

When the cow was fed the feed containing weed seeds (April 28).

When she was not thus fed (April 18).

"Most subject is the fattest soil to weeds."

2 Henry IV: IV. 4.

THE VIABILITY OF WEED SEEDS IN MANURE

Weed seeds sorted from a molasses feed, which failed for months to grow and then suddenly started up.

"Foul deeds will rise
Tho' all the earth o'erwhelm them to men's eyes."

Hamlet, I. 2.

HOMINY FEEDS

Kern & Sons, Milwaukee, Wis	Eagle,	10.8	10.5
Evans Milling Co., Indianapolis, Ind	Evans,	10	10.9
American Milling Co., Indianapolis, Ind	Homco,	..	10.1
Deutsch & Sickert Co., Milwaukee, Wis	———,	..	11.4

POULTRY FEEDS, ETC.

Park & Pollard Co., Boston, Mass	Gritless,	13.8	11.4
Lapelle Poultry Food Co., Swanton, Vt	Scratch,	10	10.8
Lapelle Poultry Food Co., Swanton, Vt	Growing,	14	18.3
Lapelle Poultry Food Co., Swanton, Vt	Chick,	13.8	10.8
Lapelle Poultry Food Co., Swanton, Vt	Dry Mash,	20	26.9
Lapelle Poultry Food Co., Swanton, Vt	Beef Scraps,	75	81.6
Jos. Breck & Sons, Boston, Mass	Brecks,	8	9.8
C. M. Cox Co., Boston, Mass	Wirthmore,	20	17.6

CALF MEAL

Blatchford Meal Co.	Blatchford,	25	26.8
Quaker Oats Co., Chicago, Ill	Schumaker,	19	20.1

VIABILITY OF WEED SEEDS IN FEEDING STUFFS

C. L. BEACH

Bulletins 131 and 133 of this Station called the attention of their readers to a danger not hitherto clearly appreciated, viz.: that several feeding stuffs sold in Vermont contained large quantities of weed seeds, many of which were viable. Claims were made quite freely by interested parties that even though some of the seeds might be viable when sold in the feed, their germinating powers were destroyed by the processes of digestion. While this claim did not appear to be based on careful trials or to be in accord with theoretical considerations it seemed worth while to attempt to determine the facts. Accordingly in April last a trial was made with a mature grade Jersey cow using a flax feed labelled "Ground Flax Flakes" but found to contain over 20 percent of apparently unground weed seeds. The feed was purchased in the open market in southern Vermont, was labelled "Ground Flax Flakes" and guarantied to carry: protein 17.34 and fat 17.37.

The diarial record indicates the scope and purpose of the trial and reads as follows:

April 10, Fed 10 pounds cut hay, 25 pounds silage, and 5 pounds of grain, composed of bran, oats, hominy and gluten feed. All this ration was thoroughly steamed at a heat sufficient to destroy the germinating power of such seeds as were present.

April 11-13.	Ditto.
April 14.	Grain ration increased to 6 pounds.
April 15-18.	Ditto.
April 16-18.	Ditto. Weight of feces voided; 31.6 pounds; 34.2 pounds; 43.2 pounds, respectively. Each day's voidings sampled.
April 19.	Substituted 6 pounds of flax feed for 6 pounds grain ration. Flax feed not steamed; roughages steamed as before.
April 20-28.	Ditto.[1]
April 26-28.	Ditto. Weights of feces voided; 45.7 pounds; 35 pounds; 37.7 pounds, respectively. Each day's voidings sampled.

Each of the several lots—six in number—three representing the voidings before the flax feed was fed and three those secured after it was added to the ration—was thoroughly mixed at the barn promptly after the weights were made and a quart sample taken. From each of these six quart samples two separate ounce samples were drawn, carefully washed and sieved and the seeds separated therefrom. One lot of six samples representing each day's voidings was submitted to microscopical survey[2] on April 28; and on April 29 the other six samples were planted in as many boxes of sterilized soil, placed under a greenhouse bench and watered daily. A check unplanted box was similarly handled. Six weeks later the diarial record reads:

June 9. Check box. No growth.
Boxes representing voidings of April 16, 17, 18—no growth.

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[1] Grain feed refused on morning of 20th, but being thereafter mixed with roughage was eaten readily.

[2] See pages 15 and 16.

Boxes representing voidings of April 26, 27, 28—
ten, seven and seven plants.[1]

On June 9 three boxes of sterilized soil received each a quantity of feces voided either on April 26th, 27th or 28th. These had been kept in sealed air-tight and cool packages. These plantings afforded in eight weeks, 19, 17 and 13 plants respectively. Three other boxes thus fertilized each with a quart of the feces of April 16, 17 and 18, and a check unmanured box showed no growth whatever in eight weeks. An average statement of the weed content of the boxes shows: dandelion 5; pigweed 3; pigeon grass 2; five-finger 3; miscellaneous 3.

Laboratory trials gave the following indications:

The total seed contents and germination results[2] from two grams of flax meal before feeding were:

Kinds of seed	Scientific name	Total seeds found	No. used in germination	No. germinated
Timothy,	*Phleum pratense L.*	35	35	4
Flax,	*Linum usitatissimum L.*	1	1	..
Small grasses,		33	27	2
Lambs quarters,[3]	*Chenopodium album L.*	226	162	24
Tumbling mustard,	*Sisymbrium altissimum L.*	248	100	43
Green foxtail,[4]	*Setaria virdis* (*L.*) Beauv.	258	194	61
Old witch grass,	*Panicum capillare L.*	17	15	3
Kale,	*Brassica arvensis* (*L.*) B. S. P.	8	8	6
Ladies' thumb,	*Polygonum persicaria L.*	11	11	..
Pepper grass,	*Lepidium virginicum L.*	6	6	3
Yellow foxtail,	*Setaria glauca* (*L.*) Beauv.	2	2	..
Five finger,	*Potentilla monspeliensis L.*	13	10	..
Vervain,	*Verbena hastata L.*	1	1	..
Common plantain,	*Plantago major L.*	2	2	..
False flax,	*Camelina sativa* (*L.*) Crantz.	5	5	3
Red root pigweed,	*Amaranthus retroflexus L.*	4	4	3
Tumble weed,	*Amaranthus graecizans L.*	23	23	10
Night shade,	*Solanum nigrum L.*	1	1	..
Dock,	*Rumex* (sp.)	2	2	..
Sedge,	*Cyperus* (sp.)	3	0	..
Mint,	*Mentha* (sp.)	3	1	..
Undetermined (15 species),		32	29	1
Totals,		938	619	163

Percentage of germination, 26.4.

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[1] A few more plants may actually have germinated and been washed away by the force of the water from the hose, the seeds being planted near the surface and but slightly rooted.

[2], [3] and [4]. See footnotes thus numbered on p. 14.

The dry material from an average ounce of washed feces voided when sterilized (steamed) feed was fed contained:

Kinds of seed	Scientific name	Number
Timothy,	*Phleum pratense L.*	3
Small grasses,		7
Common plantain,	*Plantago major L.*	1
Red stem plantain,	*Plantago Rugellii Dc.*	1
Ladies' thumb,	*Polygonum persicardia L.*	2
Five finger,	*Potentilla monspeliensis L.*	4
Barnyard grass,	*Panicum crusgalli (L.)* Beauv.	1
Yellow foxtail,	*Setaria glauca (L.)* Beauv.	1
Tumbling mustard,	*Sisymbrium altissimum L.*	1
Lambs quarters,	*Chenopodium album L.*	35
Night-flowering catch-fly,	*Silene noctiflora L.*	2
Old witchgrass,	*Panicum capillare L.*	1
Chickweed,	*Stellaria media*, Smith	3
Undetermined (7 species)		7
Total,		69

These seeds were all placed in germinators, but none showed signs of germination even after prolonged trial.

When, however, the miscroscope and the germinators were applied to the dry material obtained from an ounce of the washed feces which were voided when the flax feed was added to the otherwise sterilized (steamed) ration another tale was told. The number of seeds was increased fifteen fold, and from four to five percent of them germinated readily as may be seen from the following tables.

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[2] The identification and germination work represented in this and succeeding tables was done by Mr. N. J. Giddings, Assistant Botanist.

[3] The lambs quarters seeds were divided into two lots, one of which contained seeds apparently uninjured, and the other containing seeds which were more or less injured though possibly viable. One hundred injured seeds were placed in a germinator, and seven germinated; of 62 of the whole seeds, 17 germinated.

[4] The green foxtail seeds were similarly divided. Fifty-one whole seeds germinated out of a hundred, while but 10 of 94 broken ones germinated.

Kinds of seed	Scientific name	Total seeds found	No. used in germination	No. germinated
Timothy,	*Phleum pratense L.*	33	29	2
Other grasses,[1]		23	7	..
Flax,	*Linum usitatissimum L.*	4	4	..
Green foxtail,[2]	*Setaria viridis (L.)* Beauv.	375	200	2
Lambs quarters,[2]	*Chenopodium album L.*	285	150	12
Five finger,	*Potentilla monspeliensis L.*	16	16	..
Old witch grass,	*Panicum capillare L.*	29	27	..
Yellow foxtail,	*Setaria glauca (L.)* Beauv.	5	5	..
Kale,	*Brassica arvensis (L.)* B. S. P.	9	9	1
Night-flowering catch-fly,	*Silene noctiflora L.*	7	7	..
Dog fennel,	*Anthemis cotula L.*	2	2	1
False flax,	*Camelina sativa (L)* Crantz.	2	2	..
Curled dock,	*Rumex crispus L.*	5	5	..
Red root pigweed,	*Amaranthus retroflexus L.*	6	6	..
Tumble weed,	*Amaranthus graecizans L.*	41	39	6
Nightshade,	*Solanum nigrum L.*	1	1	..
Slender crab grass,	*Panicum filiforme L.*	1	1	..
Mint,	*Mentha* (sp.)	6	6	..
Sedge,	*Cyperus* (sp.)	1	1	..
Tumbling mustard,	*Sisymbrium altissimum L.*	131	100	13
Ladies' thumb,	*Polygonum persicaria L.*	23	23	..
Stink weed,	*Thlaspi arvense L.*	1	1	..
Pepper grass,	*Lepidium virginicum L.*	5	5	..
Undetermined (7 species)				..
Totals,		1022	656	41

Percent of seeds found which germinated, 4.
Percent of seeds used for germination which germinated, 6.2.

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[1] Much of this seed was lost by accident before germination tests were made. A few timothy and witch grass seed were similarly lost.

[2] The lambs quarters and green foxtail seeds were separated again, those which were whole from those which were slightly injured. A hundred each of the whole and injured green foxtail were placed in the germinator. None of the injured seed grew; and but two of the uninjured. A hundred injured and 50 whole lambs quarters were used; one of the injured and 11 of the uninjured germinated.

Yet another one ounce sample of feces afforded results as follows:

Kinds of seed	Scientific name	Total seeds found	No. used in germination	No. germinated
Timothy,	*Phleum pratense L.*	34	34	4
Other grasses,		14	14	..
Flax,	*Linum usitatissimum L.*	4	4	..
Whole green foxtail,	*Setaria virdis (L.)*Beauv.	194	100	5
Injured green foxtail,		192	100	1
Whole lambs quarters,	*Chenopodium album L.*	65	65	15
Injured lambs quarters,		243	100	4
Tumbling mustard,	*Sisymbrium altissimum L.*	161	100	14
Stink weed,	*Thlaspi arvense L.*	2	2	..
Ladies' thumb,	*Polygonum persicaria L.*	22	22	..
False flax,	*Camelina sativia (L.)* Crantz.	2	2	..
Kale,	*Brassica arvensis (L.)* B. S. P.	9	9	..
Nightshade,	*Solanum nigrum L.*	1	1	..
Night-flowering catch-fly,	*Silene Noctiflora L.*	6	6	..
Curled dock,	*Rumex* (sp.)	1	1	..
Other dock,	*Rumex Crispus L.*	5	5	..
Mint,	*Mentha* (sp.)	8	8	..
Tumble weed,	*Amaranthus graecizans L.*	41	41	5
Red root pigweed,	*Amaranthus retroflexus L.*	9	9	1
Old witch grass,	*Panicum capillare L.*	24	24	2
Chickweed,	*Stellaria media*, Smith	6	6	..
Five finger,	*Potentilla monspeliensis L.*	12	12	..
Pepper grass,	*Lepidium virginicum L.*	5	5	..
Switch grass,	*Panicum virgatum L.*	1	1	..
Polygonum,	*Polygonum* (sp.)	1	1	..
Undetermined (13 species)		20	20	2
Totals,		1062	692	53

Percent of seeds found which germinated, 5
Percent of seeds used for germination which germinated, 7.7

The germination tests were continued for three weeks, at the conclusion of which many of the seeds of lambs quarters, foxtail and some other species remained hard, indicating a likelihood of their ability to germinate in time; but molds had overgrown the material to such an extent that it was deemed best to discontinue the trial. It would appear, therefore, that the statement as to germination percentages, viz.: 4 and 5 per-cents, is likely to be an understatement.

Weed seeds sorted from this feed were placed rather more than half way down in a 100-ton silo full of mature silage when it was filled about October 1. These were taken out early in December, planted and many of them germinated. Laboratory germination tests also indicated that the heat, fermentation and pressure of the silage did not inhibit germination.

A lot of seeds sorted from a molasses fed sown in a flat showed no germination for many months, and then suddenly and for no appreciable reason a vigorous and characteristic weed seed growth occurred. It is well understood that some weed seeds lie dormant in the soil sometimes for years before germination.

The Maryland Station[1] reports the results of an interesting series of trials upon the effect of animal digestion and of manurial fermentation upon the vitality of seeds. Some fifty-two varieties of "the most malignant weed seeds found in Maryland" were used. Nine of these have been identified as seeds present in the molasses or flax feeds sold in Vermont. Germination of these fifty-two varieties in a germination box during twenty days varied all the way from 0 to 100 percent. About three-eighths of the seeds representing the nine varieties representative of those found in Vermont feeds germinated within three weeks.

Representative lots of each of these weed seeds were placed in the midst of piles of horse and of cow manure which reached 201° and 168° F. temperatures with means of 134° and 120° respectively. After two months had elapsed the seeds were withdrawn and planted, but no growth ensued. They could be easily crushed between the fingers, indicating that they had rotted and that their vitality was destroyed.

A similar trial lasting over a month resulted in failure to germinate; but six of the lots showed seeds which were still firm and uncrushable.

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[1] Md. Sta. Bul. 128 (1908).

The feces of calves fed considerable numbers of diverse weed seeds were used as a top dressing; were spread directly from the stable being plowed under; and were dropped at random as at pasture. The conditions of these trials were artificial but were held to represent as fairly as might be these three conditions of manurial usage. The essential results were:

Direct hauling to the field and top dressing; 12.8 percent of the seeds fed germinated within sixty days in sterile soil.

Direct hauling of feces to the field and plowing under; 2.3 percent of the seeds fed germinated within sixty days in sterile soil.

Direct hauling of the feces to the field and spreading at random as if dropped at pasture; 3.1 percent of the seeds fed germinated within sixty days in sterile soil.

The data obtained in the Vermont and Maryland experiments expressed in terms of percentages seem small. 6.2, 7.7, 12.8, 2.3, 3.1 are not impressive figures. They tend to convey the idea that after all the danger is not great. If, however, the proposition is stated in another way the danger seems more threatening. And the writer deems this latter the clearer and better method of expression.

The calculated noxious seed contents in eighteen samples of molasses and flax feeds taken in the 1907 Vermont inspections ranged from 1,150 to 131,100 per pound. In each case more or less of these seeds proved to be viable. Using the lowest figure—1,150—and the lowest percentage of germination of any of the trials reported by either station of the seeds recovered from the feces—2.3 percent—calculation indicates that the feeder buys 26 to the pound. He buys in each 100 pound feed sack 2,600 potential new weeds, all of which may be expected to pass in the seed form unharmed through the cow's digestive tract and to grow when they reach the field. And when one considers how far apart are 1,150 and 131,000 and how wide the difference is between 2.3 percent and 12.8 percent; when one remembers that there is no surety that all or even most of the voided seeds which were capable of germination did actually germinate within the six or eight week trials; one may well doubt the wisdom of the purchase of feeds carrying material percentages of weed seeds and vouch for the wisdom of the enactment of the amendment to the Public Statutes just passed by the General Assembly which reads as follows:

SEC. 4987[1]. Adulterations; exceptions; penalty. A person who adulterates whole or ground grain with milling or manufactured offals, or with a foreign substance, or bran or middlings made from the several grains or the mixtures of wheat bran and middlings known in trade as mixed feed, with a foreign substance for the purpose of sale, unless the true composition, mixture or adulteration thereof is plainly marked or indicated upon the packages containing the same, or in which it is offered for sale; or a person who uses in the manufacture of a compounded feeding stuff other than poultry feeds any wheat screenings *or material containing weed seeds to such an extent that the proportion of weed seeds shall be in excess of 2 percent by weight of such compounded feeding stuff,* unless a statement of such use of wheat screenings *or materials containing weed seeds* is plainly marked or indicated upon the packages containing the same or in which it is offered for sale; or a person who knowingly sells or offers for sale whole or ground grain, bran or middlings which is so adulterated, unless the true composition, mixture or adulteration is plainly marked or indicated upon the package containing the same, or in which it is offered for sale; *or a person who knowingly sells or offers for sale a compounded feeding stuff containing over 2 percent by weight of weed seeds* unless statement of such use of wheat screenings *or material containing weed seeds* is plainly marked or indicated upon the packages containing the same or in which it is offered for sale, shall be fined not more than one hundred dollars nor less than twenty-five dollars for each offense.

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[1] Amendment *italicized.*

Of course it should be clearly understood that the data shown above represent calculated results and not those obtained in actual trial. 131,100 seeds were not counted; neither have the 2,600 potential new weeds in the seed form been picked out of any feed sack. But these calculations are based on actual counts and on actual feeding tests. Furthermore, it should be understood that the Vermont trials were made with a flax feed, and that the Maryland trials were made with seeds representative of the malignant weed flora of that state, without particular regard apparently to whether they were or were not commonly found in commercial feeds as offorded in Maryland markets. However, the essential similarity in the general character of the weed seed contents of various molasses and flax feeds as hitherto sold on the Vermont market (as shown in bulletins 131 and 133); and the fact that more or less of these noxious seeds present in samples drawn representing every feed of this class except one were found to be viable; these considerations would seem to justify the conclusion that the results obtained with the particular brand of feed used in the trials herein reported may reasonably be expected to be applicable in kind if not in extent to other feeds containing similar weed seeds wherever such are viable.

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 139

Forest Service Publication No. 1.

MARCH, 1909.

Preliminary Statement regarding the Forestry Problems of Vermont.

BURLINGTON:
FREE PRESS PRINTING COMPANY,
1909.

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Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 139: PRELIMINARY STATEMENT REGARDING THE FORESTRY PROBLEMS OF VERMONT

FOREST SERVICE PUBLICATION No. 1

By Austin F. Hawes, State Forester

The purpose of this preliminary publication is to explain in a brief way, for the benefit of those unacquainted with the subject, what forestry is; to outline the work of the state forester's office; and to give instructions regarding one of the most important branches of forestry, namely, forest planting. Other publications will follow from time to time, containing information about the various forestry problems of Vermont.

I. Definition of Forestry

Forestry is the cultivation of a forest crop; just as horticulture is the cultivation of gardens; and as agriculture in a broad sense is the cultivation of the soil for food products, etc. The important forestry measures fall into three classes,—

(1) Planting forests.

(2) Improvement of growing forests.

(3) Harvesting mature forests in such a way that a young forest of the valuable kinds will replace the removed timber.

Planting is the phase of the subject which first appeals to land owners, and has always constituted the first step in forestry. This is because the work is simple and the results are soon evident. In New England, especially, where there is so much land formerly farmed but now lying idle, forest planting is bound to be an important form of investment. (See pp 25-26).

The improvement of woods is brought about chiefly by thinnings, which correspond to the weedings or cultivation of the garden crop. It is just as important that man should assist nature in regulating the supply of light and moisture for the trees of a forest as for turnips or potatoes. There are few soils too deficient in chemical constituents to support forest growth, so that fertilization is unnecessary and impracticable; but the retention of moisture in the soil and a sufficient supply of light are essential. In many parts of Vermont the removal of these poorer trees can be done profitably. Even if the proceeds are less than the cost,—and it must be remembered that farm weeds bring no returns,— the expenditure should be considered an investment, just as that for planting; and will, if made judiciously, be returned with interest in the form of valuable mature timber.

The most difficult forestry operation, and therefore the one least practiced, is the harvesting of mature timber in a conservative manner, so as to secure natural reproduction. Lumbermen who have cut land clean are often willing to invest in replanting the land which by proper cutting might be covered with a natural young growth. To be sure, this provision for a second growth calls for an investment, and it is sometimes a difficult question to decide whether a small investment in providing for a natural seeding or a large one in establishing plantations is preferable. In general, however, natural reproduction should be secured wherever possible, and plantations confined to open lands.

FORESTRY FOR LUMBERMEN

From the above references to investments it is evident that forestry is a business of a permanent or at least long time duration. In this it differs from past lumbering, which in this country has been largely a speculative business—the purchase of timber tracts at low figures followed by appreciation of values due to a growing scarcity of lumber. As long as lumbermen could continue this process of cheap purchase followed by denudation, their interests were opposed to forestry. In a small way this is still done by the portable mill man. Those men who have thousands or hundreds of thousands of dollars invested in sawmills and pulp concerns now find themselves confronted with the necessity of getting their supply further and further from the mill, with the prospect that in the not distant future the supply will be exhausted. For this reason these men must in the future be the strongest advocates of forestry, and many have already become so. To manage their large tracts under forestry principles will require the investment of considerable sums of money. Good forestry will secure the greatest permanent net income from this investment, just as good railroading demands a permanent rather than a temporary income.

FORESTRY FOR FARMERS

While the farmers of Vermont form a larger class of land owners than the lumbermen, their land holdings are smaller, and they have been accustomed to rely for their annual income only on the cleared part of the farms. The woodlot has been held as a sinking fund upon which to draw as a last resort in financial trouble, or for some special purpose. The best farmers, who are continually bringing up the productive capacity of their fields, have entirely overlooked the fact that their woodlots are producing only a small portion of the income which they could produce. To the owner of one hundred acres of woodland it is an important question whether that woodland is deteriorating or improving; and whether it is producing annually one-half a cord per acre, worth as stumpage fifty cents, or five hundred feet of lumber, worth four dollars. The figures represent a difference in his annual income of from fifty dollars to four hundred dollars, and they are not extremes. The farmer must not make the mistake of supposing that this income is to be removed each year. It may be necessary to leave it for a number of years, but so long as his woodlot is maintained in good condition he can be just as sure that he is saving this income as if he deposited it in a bank. The only way to maintain this condition is by thinnings, and he can make these economically by cutting his year's wood supply, and that which he wishes to sell, from the poor trees here and there, instead of cutting clean. There is hardly a farm in the state upon which there are not some open areas which are better adapted for producing forest than for other purposes. These should be cleared and planted.

Too many farms have been sold for less than the value of the timber on them. When the trees are mature, they should be sold at a stumpage price; or at least the price received for the lot should be based on the amount of timber and current stumpage values. Forestry principles require that woodland shall no longer be stripped and left naked, and the farmer is best able to enforce this requirement.

FORESTRY FOR THE OWNER OF COUNTRY ESTATES AND FOR INVESTORS

We have pointed out the two classes of land owners most affected by forestry; lumbermen and farmers. There is still a third class, which, although not really so vitally interested, has nevertheless led in the forestry movement. In this class are people who have purchased estates in the country; summer hotel companies; recreation camps; water companies; and a growing class of moneyed men who are buying forest property primarily as a good investment. These owners are all interested in having every portion of their land producing what it is best fitted for, and especially desire to grow forests on account of their beauty. Water companies have a further interest in that their water sheds can be maintained in the best condition only by a forest cover.

THE INTEREST OF THE TOWNSHIP IN FORESTRY

The chief interest of a township in forestry, as in any general subject, is a financial one. If the land owners of a community find it to their interest to practice improved methods of agriculture and forestry, it is no less to the advantage of the town government that these be practiced. With towns of rough topography and comparatively little farm land, the condition of the forests may make the difference between prosperity and pauperism. Forest property properly maintained may supply work and bear the burden of taxation for a considerable population. But as soon as it is wasted, the demand for labor is lost, assessable value is destroyed, so that the rate of taxation must be increased until it may induce depopulation.[1]

In many townships the aesthetic value of forests cannot be overlooked. There is a money value as well as a sentimental value in this, for the industries dependent upon a summer population can no longer be overlooked in Northern New England.

It is therefore the duty of the officers of such townships to develop the forest fire service as prescribed by law, so that forest property shall be more secure; and to realize that excessive taxation of woodland will only hasten the destruction of the property and permanently impoverish the town, whereas an equable taxation that shall encourage forestry will be its best policy.

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[1] In this connection, see article in Vt. St. Bd. Agr. Rpt., page 71-74. 81-83. (1903)

VERMONT'S INTEREST IN FORESTRY

The interests of the state in forestry are the same as those of the township on a larger scale. The importance of the lumber industry to Vermont is shown by the following table:

LUMBER CUT OF VERMONT, 1906—514 MILLS

Species	*M. feet*	*Total value*
White Pine	24,944	$ 433,748
Hemlock	56,042	925,336
Spruce	136,867	2,366,094
Maple	34,859	530,249
Basswood	9,482	154,259
Birch	29,577	454,033
Beech	14,976	205,981
Ash	5,184	106,072
Others	17,491	298,232
Total	329,422	$5,474,004

OTHER FOREST PRODUCTS

	Total value
4,760 slack barrel staves	$ 25,050
8,990 cords hemlock bark	64,473
34,968 cords pulp wood	290,384
3,579 M board feet used in veneer	44,276
4,779,870* lbs. maple sugar	464,132
160,918* gals. syrup	134,821
	$1,023,136

Just how much the fuel wood, railroad ties, poles, etc., cut in the state would value we have no means of knowing, but it is safe to assume that it would be between two and four million dollars, so that the total annual product of the Vermont forests is probably about ten million dollars.

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*These are figures for 1899, a year in which the sugar yield was abnormally low.

The census of 1900 gave the area of Vermont as 5,846,000 acres. This land area may be classified as follows:

Forest and waste land within farm boundaries	2,597,000 acres	= 44%
Forest and waste lands not within farm boundaries	1,122,000 acres	= 20%
Total area of forest and waste land	3,719,000 acres	= 64%
Improved farm land, including pasture	2,127,000 acres	= 36%

While it is possible that some forms of agriculture might be practised on some of the waste land, it is evident that considerably over half the state's area should be devoted to the production of forests; and that forestry is therefore of very vital financial importance to the state.

The total value of food products of the state, exclusive of live stock,[1] is approximately $25,000,000. The interesting thing shown by these figures is that the average gross income from the farmed land approximates $11.70 per acre, while from the woodland it approximates $2.70. Undoubtedly the latter figure is much below what it should be, even if the annual cut represented the annual growth, as it does in farm products. As a matter of fact this forest revenue is very largely drawn from the principal or capital, and therefore does not represent income. Statistics show that this is the case, and that the cut is diminishing.

VERMONT'S LUMBER CUT

1880	322,942,000	feet
1890	370,155,000	"
1900	365,869,000	"
1906	329,422,000	"

Defebaugh, commenting on this decreased production of Vermont in his "History of the Lumber Industry of America," says;"Inasmuch as the mechanical advantages for lumber harvesting are greater than ever and the demand for lumber increasing, the only conclusion is that the shrinkage is due to the disappearance of the forests."

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[1] The value of live stock is not included because it is comparable to the finished product of the forest, whereas our values are for raw materials.

Locust and Scotch Pine in State Nursery.

White Pine Seedlings in State Nursery.

Besides the necessity for maintaining these great forest industries and increasing the forest productivity, there are other reasons why the state must take an active part in the National forestry movement. The recent report of the National Conservation Commission is conclusive evidence that the timber resources of the country are fast disappearing, and that a timber famine is imminent. This report says that the total yearly growth of our forests is less than seven billion cubic feet; while twenty-three billion cubic feet are cut, or more than three times the growth. It also says that fully fifty million acres of forest land are annually burned over in the country. Although Vermont, on account of its small size, is the twenty-eighth state in order of their importance as timber producers, it is not less important that the state bear its share in warding off this famine.

Recent droughts, which have been so serious in some localities, indicate the advisability of maintaining a forest cover for the protection of springs and brooks. Although there is little evidence that forests actually affect rainfall, their value for holding the snow in spring and thus preventing floods, and for retaining moisture in the soil, is a well established fact.

II. VERMONT'S BEGINNINGS OF FORESTRY—THE STATE FORESTER'S OFFICE

The legislature of Vermont at its recent session provided for the creation of a State Board of Agriculture and Forestry, and the appointment of a State Forester. In doing this the state follows the example of Connecticut, Massachusetts and Rhode Island in New England; and of California, Indiana, Maryland, Michigan, Minnesota, New Jersey, New York, Pennsylvania and Wisconsin in other parts of the country.

Inasmuch as the first step toward the practice of forestry must be the reduction of damage by forest fires to a minimum, the most important duty of the state forester is to increase the efficiency of the warden service and inaugurate any other measures necessary for doing away with these fires. A study of the fires which occur in the state will be necessary before recommendations along these lines can be made.

American institutions are opposed to governmental regulation of private property, so the progress in forestry must be along two lines,—

(1) Administration of lands owned by Nation and State.

(2) Instruction of land owners in the methods, purposes and advantages of practicing forestry.

All of the National forests, comprising an area of about 190,000,000 acres, are west of the Mississippi River. While it is possible that the government may be warranted in purchasing certain forest tracts in the East, it is probable that no such need will arise in Vermont. The state has too proud a history to ask for National assistance in dealing with a problem which it is itself able to handle.

In this same enactment, the General Assembly made provision for the purchase of state forests. The present appropriation makes an immediate beginning in this line possible; and it is probable that considerable areas, especially in the Green Mountains, will in time be acquired and managed by the State. The purpose of these tracts is primarily to raise valuable timber, but it will also be educational, insofar as they afford examples of good forestry for the benefit of such as visit them. There are probably many land owners in the state who would be interested in having their land managed under forestry principles, but are not in a position to carry out this wish themselves. It is hoped that many such owners will donate tracts to the state to be managed as permanent memorials of their families or friends. Any owner contemplating such a donation may inquire concerning its disposition, either addressing J. L. Hills, Secretary of the State Board, or A. F. Hawes, State Forester, Burlington, Vt.

Next in importance to the prevention of forest fires, is the education of land owners so that they may carry out forestry principles on their own land. As already pointed out, the example furnished by the state forests will be the most effective means of bringing this about.

Investigations and experiments will be made by this office to obtain accurate information about the various forestry problems of the state, and the results will be published from time to time. In the meantime the state forester will be glad to meet granges and other organizations and to explain the purposes and results of forestry methods. He is prepared to give illustrated lectures when desired. Applications for talks should be sent in at least three weeks in advance of the desired time, so that if possible arrangements can be made to give several talks on a trip. Correspondence is especially invited on all forestry topics.

Interest in forest planting has grown so much during the past few years, and our nursery companies have done so little to meet the growing demand for stock, that it has become imperative to find a supply of material for land owners if there is any expectation that they will carry out the recommendations for planting. Until the nurseries make some such adequate provisions at reasonable prices, this office will act either as broker for the farmer, purchasing the stock at wholesale rates and selling at the same prices; or as nurseryman. The state already has a well established nursery. This will be enlarged at once, with the hope of supplying in a few years a large amount of material. In the meantime the aim of the office will be rather to furnish small orders to a large number, so that every land owner may become interested by the time a large supply is available.

III. INSTRUCTIONS REGARDING FOREST PLANTING

Bulletins 120, 127 and 132 of the Station, available on request, give a full account of the advisable methods of forest planting. the state.

The species which can be recommended are: Three species of pine, the white, scotch, and red or Norway; the Norway spruce and European larch;; and of the deciduous trees, the white ash and the black locust in the lower altitudes, and chestnut in the southern portion of the state.

The white pine is native throughout the state, and is the most valuable tree in New England. It grows rapidly and produces dense stands. The following figures give the results of measurements of several white pine plantations in Connecticut, where the conditions are less favorable than in Southern Vermont.

Name	Age, years	Approximate area, acres	Number of live trees per acre	Total yield per acre. Feet, B. M.	Mean annual growth. Feet, B. M.	Value stands per acre
Greenfield Hill	22	10	1,312	12,280	558	$ 61.50
Shakers	31	100	1,164	15,052	486	75.25
Windsor	50	8	276	41,720	834	291.70
Davis	70	4	524	60,360	862	422.80

The Scotch pine can be especially recommended on account of its very rapid growth as a young tree. On the poorest soils it makes a remarkable showing in a few years. It is also free from the attacks of the pine weevil, which injures the white pine.

The Norway or red pine is a native of Vermont. Its rate of growth is about the same as that of the white pine, and it is also free from the attacks of the pine weevil. While the lumber is slightly inferior to that of white pine, it should be widely planted as soon as there is a supply of seedlings available.

Norway spruce should not be planted so much on the sandy land as in situations with a somewhat heavier soil. It is more rapid growing than our native spruce, and apparently the lumber is equally good.

The European larch differs from our native tamarack in being a tree of the uplands rather than of the swamps. It can be recommended for planting where the soil has a fair mixture of loam, and is especially recommended for southern slopes.

Forest planting in the northern part of the state should be wholly with conifers. But in the southern part the chestnut may be profitably planted where the soil is fairly good and not too dry; and the white ash in still moister and cooler situations. There is now a chestnut disease working in New York and Connecticut which threatens to do considerable damage, and until more is known about it planting should be on a small scale.

The black or yellow locust may be planted on soils too poor for the ash and chestnut. It is a rapid grower, and the wood is valuable for its lasting qualities. Unfortunately it is often damaged by a boring insect.

SEEDING AND PLANTING

Experience in this country as well as abroad has shown that planting is much preferable to seeding. Satisfactory results can never be obtained from sowing tree seeds on unprepared land. If the land is free from rocks, so that it can be plowed and harrowed, by the application of a considerable supply of seed a stand can be secured. Other methods are:—To plow furrows every six feet, or to stir up the soil every six feet with a mattock or hoe. However, the forest resulting from any method of seeding is irregular, is three or four years behind a planted forest of the same age, and is practically as expensive to make as is a successful plantation.

CHARACTER OF STOCK ADVISED

While woods-grown seedlings can sometimes be secured cheaper than nursery stock, they are much less satisfactory. Grown in the woods, their root systems and light foliage are poorly adapted for transplanting, so that many of them die.

For the pines, three year old nursery stock gives the best results. This may be either of seedlings which have remained in the seed bed three years, or which were transplanted into nursery rows at the end of their first or second year, in which case they are called transplants. Two year seedlings or transplants can only be used on land which is free from brush or strong grass growth. As it takes them two or three years longer to start growth than the older stock, they are less satisfactory.

For the Norway spruce three or four year old stock should be used, preferably four year transplants.

For European larch, two year stock is preferable.

For chestnut, one or two year seedlings should be used.

For white ash, stock two to four feet high should be used.

For black locust, one year seedlings should be used, as older material is difficult to transplant.

SOURCE OF SUPPLY

Where a land owner contemplates planting over one hundred acres of land, it may be cheaper for him to raise his own nursery stock. The chief disadvantage in this is that the time of final planting must be postponed two or three years. This office will be glad to instruct any who wish to establish private nurseries.

There are several nursery companies in America which raise seedlings of the above species, but up to the present time they have raised them on rather a limited scale, chiefly for ornamental purposes, and consequently they have been too expensive for forest planting investments.

In order to furnish such a supply, the legislature made two years ago an annual appropriation of five hundred dollars for nursery purposes. A large supply of stock was sold to land owners last spring. The material now on hand is as follows:—

		Cost per M.
White pine 2 yr. seedlings......	30,000	$3.50
White pine 4 yr. transplants......	6,000	
Scotch pine 2 yr. seedlings	27,500	4.00
Scotch pine 4 yr. transplants.....	1,000	
Red pine 3 yr. transplants........	4,000	
Norway spruce 2 yr. seedlings....	1,500	
Norway spruce 3 yr. transplants..	1,000	
Arborvitae 3 yr. transplants......	1,000	
	72,000	

The material for which a price is given is ready for distribution; the remainder is reserved for use on state lands.

The nursery also has 400,000 one year seedlings, some of which will be ready for distribution next year. It will be much enlarged this year, so as to provide a large amount of stock for future years. As there is no available supply of three year old native stock, we have secured from a German nursery two hundred thousand three year transplants of white pine which will be for sale to land owners at cost price. The cost of these trees at the nursery is $2.00 per M; but as there is a duty of $1.00 and 15 percent ad valorem, and the freight and packing charges must also be added, the final cost will probably be between four and five dollars per M. We have also secured from nurserymen 15,000 three year old Norway spruce which will be sold at $7.00 per M. Written orders for any of this material will be considered in the order in which they are received. Not more than 20,000 trees can be supplied to any one land owner, and orders for less than 500 will not be considered. Orders may be addressed:—A. F. Hawes, State Forester, Burlington, Vt.

TIME OF PLANTING

The best time for planting is as early in the spring as possible after the frost is out of the ground. This will be from the middle of April to the middle of May, although the season may safely be extended until the first of June in the case of the pines. No trees should be transplanted during the growing season.

NUMBER OF TREES PER ACRE

The number of trees which should be planted on an acre depends somewhat on the purposes of the plantation and the kind of land. On the poorer soils more trees should be planted than on good soils; and for clear lumber more trees should be planted than for box boards. Close planting brings about an early pruning of the lower limbs, and forces the trees up to get light from above.

For an average plantation 1,500 trees per acre is the best number. This is equivalent to a spacing of five by six feet.

METHOD OF PLANTING AND COST

Planting has been done on a large scale on the state land in Union, Conn., for $8.70 an acre, including labor and a charge for trees of $3.75 per thousand. On the arrival of the trees from a distance they should at once be heeled in near the place of planting, preferably in a shaded, well-drained situation. Not more than five hundred trees should be taken out at one time for a crew of three planters. The bundles should be untied and the roots puddled in a thick mud. They should be protected in the basket with wet moss or cloths, and the roots should never be exposed to the air for a minute. A still, cloudy day early in spring when the ground is moist is most suitable for planting.

The method of planting found to be most efficient and economical is with crews of four men. Three men work abreast with mattocks, keeping straight lines by sighting on poles placed six feet apart at the other end of the field. One man or boy carries a basket with the trees and hands them to the planters as they are required. The sod should be somewhat scraped away by the mattock. The mattock is then struck down into the earth, the handle is raised and somewhat twisted, making a small hole just large enough for the little tree. The earth is then pressed firmly about the roots with the foot, the mattock not being removed until the tree is set. A crew of four men in open pasture free from brush and stones can plant 4,000 trees a day without much trouble. In very stony or brushy land they may not plant over 2,000. It pays to hire good men at high wages for this work, as for everything else. The secret of the cheapness of the planting at Union is that nearly all the labor was done by native Americans who were interested in the work.

What is said here regarding methods of planting pine applies equally well to the other species.

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VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 140

MARCH, 1909

Commercial Fertilizers

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INA RAND, Stenographer.
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☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 140: COMMERCIAL FERTILIZERS

By J. L. Hills, C. H. Jones and H. L. Miner

I. INTRODUCTION

The fertilizer law[1] provides that each package of commercial fertilizer shall carry a guaranty statement showing the minimum percentages of nitrogen, of potash soluble in distilled water, and of soluble, reverted, insoluble, available and total phosphoric acids. It further provides that the Experiment station shall sample, analyze and publish the result of the analyses of the goods as actually found on sale. It still further provides that the Station, in its yearly bulletins dealing with commercial fertilizers, shall not only state the results of analyses, but that there shall also be published "additional information in relation to the character, composition, value and use" of the goods. It further directs that these "results" and this "information" be published "as promptly as the progress of the analyses will allow and as frequently as time and means permit." Two bulletins are issued each spring; one early in April, the other in June or July. The first shows the analyses of about sixty brands, the valuation schedule, a discussion of its use, a table of analyses for five years, etc. The second issue displays the analyses of all the brands collected, the composition of the same for five years, contains a general review of the trade of the state, including statements as to the quantity and quality of the plant food sold in the sundry brands, considers the comparative values of the average goods of the current and preceding years, outlines the relationship between selling prices and valuations, and discusses some one or more phases of the fertilizer problem, taking usually a different phase yearly.

The present bulletin contains analyses of samples representing 56 brands. The second and larger bulletin containing the analyses of the remaining brands, together with a reprint of the analyses given in the present bulletin, as well as a discussion such as is above referred to, will be issued late in June or early July.

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[1] Chapter 213: Sections 4973-4982, 4989-4993 P. S.

All analyses represent samples taken by the station sampling agents from this year's shipments in the hands of local dealers. Particular attention is called to the analyses for five years past of the various brands shown on pages 54-60. This table should be of service to the early buyer.

For detailed data regarding the meaning of the terms used in fertilizer analysis, the sources of crude stock or raw materials used in manufacture, the commercial and agricultural values of fertilizers, the arguments in favor of and methods of home-mixing, the rational and economical selection, purchase and use of fertilizers, the reader is referred to bulletins 93, 99, 108, 123, 130 and 135, sent free on request. The remarks contained in these bulletins were written in 1902 to 1908, but are just as applicable to the purchase and use of fertilizers in 1909 and succeeding years as when first penned. The reader of this bulletin who does not own them, and wants either or all of them, has but to ask to receive. (See Circular No. 1 mailed with this bulletin.)

II. VALUATION SCHEDULE

The following schedule of trade values to be used in this state in 1909 is the one agreed upon by the experiment stations of New England and New Jersey, after a careful study of prices ruling in the larger markets. For comparative purposes the schedule used last year is included in the tabulation. It will be noted that nitrogen and phosphoric acid valuations have dropped.

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS FOR 1908 AND 1909

	1908 cts. per lb.	1909 cts. per lb.
Nitrogen in nitrates	18½	16½
Nitrogen in ammonia salts	17½	17
Organic nitrogen in dry and fine ground fish, blood and meat and in mixed fertilizers	20½	19
" " in fine ground bone and tankage	20½	19
" " in coarse bone and tankage	15	14
Phosphoric acid soluble in water	5	4
" " soluble in ammonium citrate[1]	4½	3½
" " in fine ground bone and tankage	4	3½
" " in coarse bone and tankage	3	3
" " insoluble (in water and in ammonium citrate[1]) in mixed fertilizers	2	2
Potash as high grade sulphate and in mixtures free from muriate (chlorid)	5	5
Potash as muriate	4¼	4¼

These trade values are, as nearly as can be estimated, the average figures at which, in the six months preceding March 1st, the respective ingredients could be bought at retail for cash in the larger markets (Boston, New York, etc.), in the *raw materials,* unmixed. They also correspond to the average wholesale prices for six months ending March 1st, plus about 20 percent in the case of goods for which there are wholesale quotations. The valuations obtained by the use of the above figures will be found to agree fairly with the reasonable average retail price in the large markets of standard raw materials.

In applying trade values to mixed goods, organic nitrogen is valued at 19 cents a pound; nitrogen as nitrate of soda and as sulphate of ammonia at 16½ and 17 cents a pound respectively; soluble, reverted and insoluble phosphoric acids at 4, 3½, and 2 cents a pound respectively; and potash at 4¼ cents a pound, if there is sufficient chlorin to unite with all the potash; if not, it is valued at 5 cents.

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[1] Dissolved from 2 grams of the prepared sample, previously extracted with pure water, by 100 c. c. of a neutral solution of ammonium citrate, sp. gr. 1.09, in 30 minutes at 65 degrees C, with agitation once in five minutes.

A valuation is determined as follows: The percentages or pounds per hundred of each ingredient (i. e., nitrate nitrogen, ammoniacal nitrogen, organic nitrogen, soluble phosphoric acid, reverted phosphoric acid, insoluble phosphoric acid and potash), are multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

THE MEANING OF COMMERCIAL VALUES

That there may be no misconception and that the reader may clearly appreciate what these valuations are and what they are not, it is our custom to call attention repeatedly to the fact that *a station valuation does not represent the proper selling price of a fertilizer at the point of consumption.* Neither should it be inferred that the ingredients in the brand in question have of necessity the commercial value indicated. It may be greater or less than is shown. The Station does not pretend dogmatically to state what may be the commercial worth or valuation of any one of the many brands of fertilizer sold in the Vermont market, as it cannot always affirm the quality of the crude stock used, particularly the nitrogenous material. The valuation system is based on the assumption that all brands are composed solely of high grade ingredients, an assumption which is probably erroneous. "Valuations" should not be construed as showing either the agricultural or the commercial worth of a given fertilizer, but simply as showing the *retail trade value of cash-cost of amounts of nitrogen, phosphoric acid and potash, equal to those contained in a ton of the brand in question, in unmixed, standard raw materials of good quality, at the seaboard.*

Valuations thus construed, while not infallible, are helpful:

(*a*) To show whether a given fertilizer is worth its cost from the *commercial* standpoint.

(*b*) As a common basis on which to compare the *commercial* values of different brands, enabling buyers to note whether prices asked are warranted by values contained.

In 1908 the average selling price of 130 brands sold in Vermont was $31.24 per ton, the average "valuation" $20.75, and the difference, $10.49, an advance of 51 percent on the "valuation." Or, stating the case in another way, on the average one dollar out of every three was paid for expenses, while two dollars were paid for the plant food. Amounts of plant food of the best quality equal to what were contained in several brands might have been bought at retail for cash at the seaboard for half the credit price asked in Vermont.

Some buyers construe this sum—$10.49, the expense account —to be the manufacturer's profit. Such a construction is utterly unwarranted and only explicable on the assumption that in no way whatsoever have they made the slightest effort to grasp the fundamental idea of the valuation system. Only a fraction of this sum represents profit. Its main items are freight rates, and factory and sales charges. It were quite as logical to assume that the difference between the retail cost of a pair of shoes and the raw leather from which they were made were all profit.

Selling prices always exceed valuations, since the latter show only the seaboard values of the unmixed ingredients and do not include the many other necessary and legitimate charges which accompany the manufacture and sale of mixed goods. If the selling price does not exceed the valuation more than 30 or 35 percent it may not be too high, but in proportion as the excess increases beyond this point there is reason to question the economy of the purchase.

For a full discussion of this matter, see pages 81-86, bulletin 99.

III. OBSERVANCE OF THE FERTILIZER LAW

The following companies have paid licenses on the brands specified. Agents and intending purchasers are warned against the handling of other brands, unless bought for personal use and not for sale. Agents are also warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the one hundred dollars license fee:

AMERICAN AGRICULTURAL CHEMICAL CO., 2 RECTOR ST., NEW YORK, N. Y.

Grass and Lawn Top Dressing.
Grass and Oats Fertilizer.
High Grade Ten percent Manure.

H. J. Baker & Co. brands:

Complete Potato Manure.
Harvest Home Fertilizer.
Standard UnXlD Fertilizer.

Bradley Fertilizer Co. brands:

Alkaline Bone and Potash.
Complete Manure, Potatoes and Vegs.
Complete Manure with 10% Potash.
Corn Phosphate.
Eclipse Phosphate.
Niagara Phosphate.
Potato Fertilizer.
Potato Manure.
Vermonter for All Crops.
XL Superphosphate of Lime.

Clark's Cove Fertilizer Co. brands:

Bay State Fertilizer G. G.
King Philip Alkaline Guano.
Potato Fertilizer.

Cleveland Dryer Co. brands:

Fertilizer for All Crops.
Potato Phosphate.
Superphosphate.

Crocker Fertilizer and Chemical Co. brands:

Ammoniated Corn Phosphate.
New Rival Ammon. Bone Superphos.
Potato Hop and Tobacco Phosphate.
Potato Special.

Cumberland Bone Phosphate Co. brands:

Guano.
Potato Fertilizer.
Superphosphate.

L. B. Darling Fertilizer Co. brands:

Farm Favorite.
General Fertilizer.

Great Eastern Fertilizer Co. brands:

Garden Special.
General Fertilizer.
Northern Corn Special.
Potato Manure.

Pacific Guano Co. brands:

Nobsque Guano.
Potato Special.
Soluble Pacific Guano.

Quinnipiac Co. brands:

Climax Phosphate.
Corn Manure.
Market Garden Manure.
Potato Phosphate.

Read Fertilizer Co. brands:

Farmers' Friend Superphosphate.
High Grade Farmers' Friend Superphos.
Leader Blood and Bone.
Practical Potato Special.
Standard Superphosphate.
Sure Catch Phosphate.

H. F. Tucker Co. brands:

Imp. Bone Superphos., All Crops.
Imp. Bone Superphosphate for Corn.
Imp. Bone Superphos. for Potatoes.

Williams & Clark Fertilizer Co. brands:

Americus Corn Phosphate.
Americus High Grade Special.
Americus Potato Manure.
Americus Potato Phosphate.
Prolific Crop Producer.
Royal Bone Superphos. for All Crops.

ARMOUR FERTILIZER WORKS, 861 Calvert Bldg., Baltimore, Md.

Corn Special.
Complete Manure.
General Farm.
High Grade Potato.
Oats and Clover Special.

BOWKER FERTILIZER Co., 43 Chatham St., Boston, Mass.

Corn Phosphate.
Hill and Drill Phosphate.
Market Garden Fertilizer.
Potash Bone.
Potash or Staple Phosphate.
Potato and Vegetable Fertilizer.
Potato and Vegetable Phosphate.
Square Brand Bone and Potash.
Stockbridge Man. for Corn and Grain.
Stockbridge Manure for Potatoes.
Stockbridge Manure for Quick Growth.
Superphosphate with Potash.
Sure Crop Phosphate.
Vermont Grange Chemicals, D Brand.

BUFFALO FERTILIZER Co., William St., near city line, Buffalo, N.Y.

Celery and Potato Special.
Extra Bone with Potash.
Farmers' Choice.
Fish Guano.
General Crop.
High Grade Manure.
Ideal Wheat and Corn.

BURLINGTON RENDERING Co., North Avenue, Burlington, Vt.

Animal Fertilizer.
Special Potato Fertilizer.

COE-MORTIMER Co., 24-26 Stone St., New York, N. Y.

Columbian Corn and Potato Fertilizer.
Gold Brand Excelsior Guano.
High Grade Ammo. Bone Superphos.
New England Special Corn Fertilizer.
New England Special Potato Fertilizer.
Prize Brand Grass and Grain.

ESSEX FERTILIZER Co., 39 North Market St., Boston, Mass.

A 1 Superphosphate.
Comp. Manure for Corn, Grain & Grass.
Comp. Manure for Pots., Roots & Vegs.
Grain and Grass Fertilizer.
Market Garden and Potato Manure.
XXX Fish and Potash.

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

Animal Bone and Potash No. 2.
G Brand.
Grass and Oats Fertilizer.
Oneida Special.
Potato Manure.
Special Corn Fertilizer.
Special Potato Fertilizer.
Special Ten percent Potato Fertilizer.
Success Fertilizer.

LOWELL FERTILIZER Co., 44 North Market St., Boston, Mass.

Animal Brand for All Crops.
Bone Fertilizer for Corn and Grain.
Cereal Fertilizer.
Empress Brand.
Potato Manure.
Potato Phosphate.
Sterling Phosphate.
Superior Fertilizer.

NEW ENGLAND FERTILIZER Co., 42 North Market St., Boston, Mass.

Corn and Grain Fertilizer.
Corn Phosphate.
Peerless Fertilizer.
High Grade Ten Percent.
Potato Fertilizer.

PARMENTER & POLSEY FERTILIZER Co., 40 B North Market St., Boston, Mass.

Grain Grower Brand.
Plymouth Rock Brand.
Potato Fertilizer.
Star Brand Superphosphate.
Potato Grower.

ROGERS & HUBBARD Co., Middletown, Conn.

Grass and Grain Fertilizer.
New Market Garden Fertilizer.
Oats and Top Dressing.
Potato Phosphate.
Complete Phosphate.
Soluble Corn and General Crops.
Soluble Potato Manure.
Soluble Tobacco Manure.

SPECIAL NOTICE.—The following brands licensed for sale in 1908 are not thus licensed in 1909.

American Agricultural Chemical Co.'s; Crocker's Grass and Oats; Darling's Potato Manure; Great Eastern Grass and Oats; Buffalo Fertilizer Co.'s Vegetable and Potato; Parmenter & Polsey Co.'s Aroostook Special, Special Potato; Bowker Fertilizer Co.'s Early Potato Manure.

IV. LICENSED FERTILIZERS SAMPLED BY THE STATION

AMERICAN AGRICULTURAL CHEMICAL CO., 2 Rector St., New York, N. Y.

A 1. *High Grade Ten Percent Manure;* Bennington.

(H. J. Baker & Co. brands.)

A19. *Complete Potato Manure;* Ludlow.
C 4. *Harvest Home Fertilizer;* South Royalton.

(Bradley Fertilizer Co. brands.)

A 8. *Corn Phosphate;* Bennington.
A 5. *Potato Fertilizer;* Brattleboro.
A 7. *Vermonter for All Crops;* Windsor.
A 6. *XL Superphosphate of Lime;* Bennington.

(Clark's Cove Fertilizer Co. brands.)

C 1. *King Philip Alkaline Guano;* Randolph.

(Cleveland Dryer Co. brands.)

A12. *Potato Phosphate;* Windsor.
A13. *Superphosphate;* Windsor.

(Crocker Fertilizer and Chemical Co. brands.)

A17. *Ammoniated Corn Phosphate;* Jericho.
A16. *New Rival Ammoniated Bone Superphosphate;* Jericho.
A18. *Potato, Hop, and Tobacco Phosphate;* Hartland.
C 3. *Potato Special;* Waterbury Center.

(Cumberland Bone Phosphate Co. brands.)

C 2. *Cumberland Superphosphate;* Waterbury Center.

(L. B. Darling Fertilizer Co. brands.)

A20. *Farm Favorite;* Fairlee.
C16. *General Fertilizer;* South Ryegate.

(Great Eastern Fertilizer Co. brands.)

B 3. *Northern Corn Special;* Dorset.
B 4. *Potato Manure;* Dorset.

(Pacific Guano Co. brands.)

B12. *Potato Special;* Brattleboro.
B13. *Soluble Pacific Guano;* Brattleboro.

(Quinnipiac Co. brands.)

B15. *Corn Manure;* Cambridge.
B14. *Potato Phosphate;* Burlington.

(Read Fertilizer Co. brands.)

C 5. *Farmer's Friend Superphosphate;* Jonesville.
B16. *Standard Superphosphate;* Danville.

(H. F. Tucker Co. brands.)

B19. *Imperial Bone Superphosphate for Corn;* Ludlow.

(*Williams and Clark Fertilizer Co. brands.*)

B20. *Americus Corn Phosphate;* Dorset.
C 6. *Americus Potato Manure;* Dorset.
C 7. *Prolific Crop Producer;* Montpelier.

BOWKER FERTILIZER CO., 43 Chatham St., Boston, Mass.

B 2. *Corn Phosphate;* Norwich.
C11. *Hill and Drill Phosphate;* Williamstown.
A 3. *Potato and Vegetable Phosphate;* Norwich.
A 4. *Stockbridge Manure for Potatoes and Vegetables;* Marshfield.
C10. *Vermont Grange Chemicals, D Brand;* Plainfield.

BUFFALO FERTILIZER CO., William St., near city line, Buffalo, N.Y.

A10. *Celery and Potato Special;* Bennington.
A 9. *Farmer's Choice;* West Hartland.
A11. *Ideal Wheat and Corn;* Bennington.

COE-MORTIMER CO., 24-26 Stone St., New York, N. Y.

A15. *Columbian Corn and Potato Fertilizer;* Hartland.
A14. *High Grade Ammoniated Bone Superphosphate;* Hartland.

ESSEX FERTILIZER CO., 39 North Market St., Boston, Mass.

B 1. *Complete Manure for Potatoes, Roots and Vegetables;* Montpelier.
B 2. *XXX Fish and Potash;* Montpelier.

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

C12. *G Brand;* Plainfield.
C13. *Potato Manure;* Fairfield.
B 6. *Special Corn Fertilizer;* Jericho.
B 5. *Success Fertilizer;* East Fairfield.

LOWELL FERTILIZER CO., 44 North Market St., Boston, Mass.

B 7. *Animal Brand for All Crops;* Rupert.
C14. *Empress Brand;* Bennington.
B 8. *Potato Manure;* Montpelier.
B 9. *Sterling Phosphate;* Bennington.
C15. *Superior Fertilizer;* Essex Junction.

NEW ENGLAND FERTILIZER CO., 42 North Market St., Boston, Mass.

B10. *Peerless Fertilizer;* White River Junction.
B11. *Potato Fertilizer;* Ira.

ROGERS & HUBBARD CO., Middletown, Conn.

C 8. *Complete Phosphate;* Newport.
C 9. *New Market Garden Fertilizer;* East Berkshire.
B17. *Potato Phosphate;* Manchester.
B18. *Soluble Corn and General Crops;* Woodstock.

V. ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
A 1	A. A. C. Co. High Grade Ten Percent	1.79	1.51	3.30	*2.4*	$ 11.65	4.76	2.08	2.48	9.32	7.	6.84	6.	$6.27	10.09	*10.*	$8.57
A 19	A. A. C. Co. Baker's Complete Potato	1.51	1.89	3.40	*3.3*	12.16	5.36	1.50	1.46	8.32	7.	6.86	6.	5.92	10.18	*10.*	8.65
C 4	A. A. C. Co. Baker's Harvest Home....	......	1.26	1.26	*1.03*	4.79	6.20	3.08	2.00	11.28	*10.*	9.28	*8.*	7.92	2.24	*2.*	1.90
A 8	A. A. C. Co. Bradley's Corn Phos......	0.81	1.79	2.60	*2.06*	9.47	6.48	2.91	2.99	12.38	*10.*	9.39	*8.*	8.42	2.17	*1.5*	1.84
A 5	A. A. C. Co. Bradley's Potato Fert......	0.84	1.33	2.17	*2.06*	7.82	6.04	3.38	2.94	12.36	*10.*	9.42	*8.*	8.38	2.97	*3.*	2.52
A 7	A. A. C. Co. Bradley's Vermonter......	(a) 0.67	1.75	2.42	*2.06*	8.90	6.32	2.02	2.32	10.66	*10.*	8.34	*8.*	7.40	3.09	*3.*	2.63
A 6	A. A. C. Co. Bradley's XL Superphos	0.81	1.65	2.46	*2.5*	8.94	7.24	2.00	2.32	11.56	*11.*	9.24	*9.*	8.12	2.28	*2.*	1.94
C 1	A. A. C. Co. Clark's Cove King Philip	......	1.26	1.26	*1.03*	4.79	5.66	2.68	2.42	10.76	*10.*	8.34	*8.*	7.38	2.22	*2.*	1.89
A 12	A. A. C. Co. Cleveland Potato Phos....	0.74	1.50	2.24	*2.06*	8.14	6.38	2.78	2.48	11.64	*10.*	9.16	*8.*	8.04	3.47	*3.*	2.95
A 13	A. A. C. Co. Cleveland Superphos......	(b) 0.98	1.26	2.24	*2.06*	8.11	6.40	2.26	2.10	10.76	*10.*	8.66	*4.*	7.54	2.12	*1.5*	1.80
A 17	A. A. C. Co. Crocker's Am. Corn Phos.	0.81	1.54	2.35	*2.06*	8.52	6.68	2.42	2.26	11.36	*10.*	9.10	*8.*	7.93	1.90	*1.5*	1.61
A 16	A. A. C. Co. Crocker's New Rival......	0.20	0.96	1.16	*1.03*	4.31	6.76	2.58	2.18	11.52	*10.*	9.34	*8.*	8.10	2.21	*2.*	1.88

*Potash in brands thus marked is largely if not entirely in sulphate. ‡See definition, page 42. §As ammonia salts.
(a) As nitrates, 0.28 percent; as ammonia salts, 0.39 percent.
(b) As nitrates, 0.15 percent; as ammonia salts, 0.83 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
A 18	A.A.C.Co.'s Crocker's Pot. Hop & Tob	0.84	1.44	2.28	*2.06*	$8.24	6.60	2.49	2.95	12.04	*10.*	9.09	*8.*	$8.20	3.19	*3.*	$2.71
C 3	A. A. C. Co.'s Cumberland Pot. Fert.	0.70	1.54	2.24	*2.06*	8.16	6.14	3.10	1.92	11.16	*10.*	9.24	*8.*	7.85	3.36	*3.*	2.86
C 2	A. A. C. Co.'s Cumberland Superphos.	§0.86	1.46	2.32	*2.06*	8.47	6.58	2.10	2.08	10.76	*10.*	8.68	*8.*	7.56	2.32	*1.5*	1.97
A 20	A. A. C. Co.'s Darling's Farm Favor.	§0.87	1.37	2.24	*2.06*	8.16	6.96	1.70	1.98	10.64	*10.*	8.66	*8.*	7.55	3.17	*3.*	2.69
C 16	A. A. C. Co.'s Darling's General Fert.	0.74	0.94	1.68	*1.25*	6.01	4.66	2.92	2.38	9.96	*7.*	7.58	*6.*	6.73	4.18	*3.*	3.55
B 3	A. A. C. Co.'s Gr. East. Nor. Corn Spec.	0.63	1.65	2.28	*2.06*	8.35	5.96	2.51	2.63	11.10	*10.*	8.47	*8.*	7.61	1.75	*1.5*	1.49
B 4	A. A. C. Co.'s Gr. East. Potato Man..	0.67	1.50	2.17	*2.06*	7.91	4.72	3.89	3.29	11.90	*10.*	8.61	*8.*	7.80	3.04	*3.*	2.58
B 12	A. A. C. Co.'s Pac. Gu. Co. Pot. Spec.	0.28	1.96	2.24	*2.06*	8.37	6.20	1.94	2.84	10.98	*10.*	8.14	*8.*	7.46	3.34	*3.*	2.84
B 13	A. A. C. Co.'s Pac. Gu. Co. Sol. Pac. Gu.	(c) 0.60	1.50	2.10	*2.06*	7.70	5.64	2.36	2.52	10.52	*10.*	8.00	*8.*	7.17	1.77	*1.5*	1.50
B 15	A. A. C. Co.'s Quinnipiac Corn Man.	§0.81	1.36	2.17	*2.06*	7.92	6.28	2.75	1.93	10.96	*10.*	9.03	*8.*	7.71	2.18	*1.5*	1.85
B 14	A. A. C. Co.'s Quinnipiac Pot. Phos...	0.84	1.40	2.24	*2.06*	8.09	6.52	2.57	3.35	12.44	*10.*	9.09	*8.*	8.35	3.08	*3.*	2.62

Potash in brands thus marked is largely if not entirely in sulphate. ‡See definition, page 42. §As ammonia salts.
(c) As nitrates, 0.34 percent; as ammonia salts, 0.26 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
C 5	A. A. C. Co. Read's Farmer's Friend.	0.70	1.58	2.28	*2.06*	$8.31	6.26	2 52	2.46	11.24	*10.*	8.78	*8.*	$7.75	3.18	*3.*	$2.70
B 16	A. A. C. Co. Standard Superphos......	......	1.16	1.16	*0.82*	4.41	4.92	3.28	2.52	10.72	*10.*	8.20	*8.*	7.25	4.09	*4.*	3.48
B 19	A. A. C. Co. Tucker's Imp. for Corn..	.....	1.33	1.33	*1.03*	5.05	4.50	4.14	2.44	11.08	*10.*	8.64	*8.*	7.47	2.04	*2.*	1.73
B 20	A.A.C.Co. W.& C.Co.'s Am.CornPhos.	§0.83	1.31	2.14	*2.06*	7.80	6.76	2.09	2.25	11.10	*10.*	8.85	*8.*	7.77	2.09	*1.5*	1.78
C 6	A.A.C.Co. W.& C. Co.'s Am. Pot. Man.	0.60	1.68	2.28	*2.06*	8.36	6.02	3.14	1.96	11.12	*10.*	9.16	*8.*	7.81	3.38	*3.*	2.87
C 7	A.A.C.Co. W.&C.Co.'s Prol.CropProd.	0.28	0.91	1.19	*0.82*	4.38	3.34	4.16	2.22	9.72	*8.*	7 50	*7.*	6.47	1 67	*1.*	1.44
A 2	Bowker's Corn Phosphote................	0.63	1.16	1.79	*1.65*	6.49	4.40	3.70	3.96	12.06	*9.*	8.10	*8.*	7.70	2.29	*2.*	1.95
C 11	Bowker's Hill and Drill Phosphate....	0.74	2.00	2.74	*2.47*	10.04	6.36	3.54	2.82	12.72	*10.*	9.90	*9.*	8.70	2.04	*2.*	1.73
A 3	Bowker's Potato and Vegetable Phos.	0.49	1.30	1.79	*1.65*	6.56	4.60	3.43	4.01	12.04	*10.*	8.03	*8.*	7.68	2.24	*2.*	1.90
A 4	Bowker's Stockbridge Potato Manure	1.58	1.82	3.40	*3.29*	12.13	5.36	1.54	1.96	8.86	*7.*	6.90	*6.*	6.16	9.98	*10.*	8.48
C 10	Bowker's Vt. Grange Chem. D. Brand	§0 84	1.48	2.32	*2.06*	8.47	6.22	2.08	2.06	10.36	*9.*	8.30	*8.*	7.26	3.24	*3.*	2.75

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*Potash in brands thus marked is largely if not entirely in sulphate. ‡See definition, page 42. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
A 10	Buffalo Fert. Co.'s Celery & Potato...	(d) 0.95	0.70	1.65	*1.64*	$5.87	4.68	3.40	1.48	9.56	*9.*	8.08	*8.*	$6.71	10.64	*10.*	$9.04
A 9	Buffalo Fert Co.'s Farmer's Choice....	......	1.19	1.19	*0.82*	4.52	5.68	4.20	1.72	11.60	*9.*	9.88	*8.*	8.17	4.72	*5.*	4.01
A 11	Buffalo Fert. Co.'s Ideal Wheat&Corn	(e) 0.63	1.12	1.75	*1.64*	6.37	5.88	3.72	1.00	10.60	*10.*	9.60	*9.*	7.70	6.01	*5.*	5.11
A 15	Coe-Mort. Co.'s Col. Corn & Potato...	§0.37	0.89	1.26	*1.23*	4.64	6.44	2.52	0.72	9.68	*9.5*	8.96	*8.5*	7.20	2.56	*2.5*	2.18
A 14	Coe-Mort. Co 's High Grd. Am. Bone	§0.21	1.96	2.17	*1.85*	8.16	5.84	4.26	0 54	10.64	*9.*	10.10	*8.*	7.86	3.22	*3.*	2.74
B 1	Essex Fert. Co.'s Potato, Root, Veg...	0.84	2.46	3.30	*3.25*	12.12	4.80	1.90	1.38	8.08	*7.*	6.70	*6.*	5.72	10.17	*10.*	8.64
B 2	Essex Fert. Co.'s XXX Fish & Pot....	......	2.21	2.21	*2.*	8.40	6.16	2.14	1.54	9.84	*9.*	8.30	*8.*	7.05	3.16	*3.*	2.69
C 12	Lister's G Brand..............................	......	1.12	1.12	*0.82*	4.26	6.10	2.00	1.22	9.32	*10.*	8.10	*8.*	6.77	4.17	*4.*	3.54
C 13	Lister's Potato Manure....................	(f) 2.37	1.42	3.79	*3.3*	13.39	6.72	1.74	1.38	9.84	*9.*	8.46	*8.*	7.14	7.44	*7.*	6.32
B 6	Lister's Special Corn Fertilizer.........	§0.64	1.25	1.89	*1.65*	6.93	5.48	2.62	1.82	9.92	*9.*	8.10	*8.*	6.94	3.30	*3.*	2.81
B 5	Lister's Success Fertilizer................	......	1.44	1.44	*1.24*	5.47	6.72	2.86	1.78	11.36	*11.*	9.58	*9.*	8.09	2.14	*2.*	1.82

*Potash in brands thus marked is largely if not entirely in sulphate. ‡See definition, page 42. §As ammonia salts.

(d) As nitrates, 0.19 percent; as ammonia salts, 0.76 percent.

(e) As nitrates, 0.28 percent; as ammonia salts, 0.35 percent.

(f) As nitrates, 0.67 percent; as ammonia salts, 1.70 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
B 7	Lowell (Swift's) Animal Brand.........	......	2.74	2.74	*2.46*	$10.41	6.88	1.74	1.06	9.68	*10.*	8.62	*8.*	$7.14	4.42	*4.*	$3.76
C 14	Lowell (Swift's) Empress Brand......	......	1.47	1.47	*1.23*	5.59	5.82	2.02	0.96	8.80	*8.*	7.84	*7.*	6.45	2.19	*2.*	1.86
B 8	Lowell (Swift's) Potato Manure........	......	1.89	1.89	*1.64*	7.18	5.20	2.28	1.04	8.52	*8.*	7.48	*7.*	6.17	4.12	*4.*	3.50
B 9	Lowell (Swift's) Sterling Phosphate..	......	1.12	1.12	*0.82*	4.26	5.48	2.96	1.84	10.28	*9.*	8.44	*8.*	7.19	4.10	*4.*	3.48
C 15	Lowell (Swift's) Superior Fertilizer ..	0.70	3.19	3.89	*3.69*	14.43	4.62	2.76	1.02	8.40	*8.*	7.38	*7.*	6.04	9.93	*10.*	8.44
B 10	N. E. Fert. Co.'s Peerless Fertilizer...	.....	0.98	0.98	*0.82*	3.72	5.44	2.56	0.96	8.96	*8.*	8.00	*7.*	6.52	1.14	*1.*	0.97
B 11	N. E. Fert. Co.'s Potato Fertilizer....	.....	1.86	1.86	*1.64*	7.07	4.32	2.67	1.45	8.44	*8.*	6.99	*7.*	5.91	4.27	*4.*	3.63
C 8	R. & H. Co.'s Complete Phosphate....	0.28	1.26	1.54	*1.5*	5.71	4.36	3.36	0.92	8.64	*8.*	7.72	*7.*	6.21	6.10	*5.*	5.19
¶C 9	R. & H. Co.'s New Market Garden....	0.62	0.98	1.61	*2.*	5.80	3.42	2.74	0.72	6.88	*7.*	6.16	*6.*	4.92	10.97	*10.*	9.32
B 17	R. & H. Co.'s Potato Phosphate..... ..	0.88	1.15	2.03	*2.*	7.27	6.84	3.50	0.98	11.32	*10.*	10.34	*9.*	8.31	5.77	*5.*	4.90
B 18	R. & H. Co.'s Sol. Corn & Gen. Crops	0.81	1.93	2.74	*2.5*	10.00	2.60	4.52	2.48	9.60	*8.*	7.12	*5.5*	6.23	8.94	*8.*	7.60

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*Potash in brands thus marked is largely if not entirely in sulphate. ‡See definition, page 42. §As ammonia salts.

¶A second sample from another location exceeds nitrogen quantity by over 0.50%.

VI. ANALYSES OF LICENSED FERTILIZERS—1904-1908

	Brand	Nitrogen						Available Phospho'c Acid						Potash					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
American Agricultural Chem. Co.'s	Grass and Lawn Top Dres.	†4.90	†5.19	†4.98	†3.82	†5.40	*3.91*	5.34	5.23	6.18	5.50	6.90	*5.*	*2.82	*3.02	3.12	2.85	*4.49	*2.*
	High Grade Ten Percent...	†2.67	†2.67	†2.81	†2.74	†2.37	*2.4*	6.23	6.68	6.14	6.32	6.00	*6.*	11.45	10.40	10.80	10.75	9.88	*10.*
	Baker's Complete Potato ...	†3.44	†3.61	†3.47	†3.87	†3.44	*3.3*	6.61	6.71	6.68	7.34	6.36	*6.*	11.24	10.04	9.12	10.48	9.87	*10.*
	Baker's Harvest Home......	1.23	1.51	1.30	1.30	1.12	*1.03*	8.18	7.94	9.32	8.04	8.08	*8.*	2.10	2.10	2.41	2.00	2.00	*2.*
	Baker's Standard UnXlD..	†1.89	†2.50	†2.39	†1.82	†1.51	*1.65*	7.95	7.72	8.14	9.04	8.04	*8.*	2.16	2.26	2.68	2.04	2.24	*2.*
	Bradley's Alkaline Bone....	......	......	......	......	......	......	10.96	10.69	11.26	11.30	10.32	*11.*	2.30	2.17	2.24	2.36	1.91	*2.*
	Bradley's Comp. Pot. & Veg.	†3.53	†3.86	†3.33	†4.00	†3.49	*3.3*	7.62	7.82	8.92	8.20	8.68	*8.*	7.34	6.80	*7.58	7.88	6.73	*7.*
	Bradley's Comp. 10 Perc't..	†3.58	†3.61	†3.40	†3.58	†3.47	*3.3*	6.27	6.78	6.66	6.66	6.78	*6.*	11.06	10.30	10.64	11.24	10.25	*10.*
	Bradley's Corn Phosphate..	†2.32	†2.32	†2 21	†2.14	†2.17	*2.06*	8.05	8.01	8.68	8.52	8.36	*8.*	1.70	2.09	2.00	1.84	1.90	*1.5*
	Bradley's Eclipse Phos......	1.33	1.40	1.23	1.33	†0.90	*1.03*	8.10	7.68	8.58	7.99	9.30	*8.*	2.36	2.36	2.32	2.04	2.12	*2.*
	Bradley's Niagara Phos......	1.19	1.19	1.40	1.23	1.12	*0.82*	6.54	6.77	7.50	7.66	7.98	*7.*	1.38	1.60	1.60	1.31	1.45	*1.*
	Bradley's Potato Fertilizer	†2.28	†2.32	†2.24	†2.10	†1 98	*2.06*	8.48	8.14	8.42	8.14	8.30	*8.*	3.10	3.08	3.48	3 36	3.36	*3.*
	Bradley's Potato Manure...	†2.70	†2.77	†2.74	†2.63	†2.83	*2.5*	6.92	7.58	6.74	7.94	6.88	*6.*	5.40	5.95	5.44	5.40	6.78	*5.*
	Bradley's Vermonter.........	†2.28	†2.24	†2.17	†2.32	†2.21	*2.06*	7.83	7.52	8.20	8.38	8.18	*8.*	3.32	3.24	3.20	3.35	3.11	*3.*
	Bradley's XL Superphos...	†2.54	†2.67	†2.53	†2.70	†2.95	*2.5*	9.19	9.48	9.28	9.00	9.08	*9.*	2.40	2.27	2.44	2.33	2.71	*2.*
	Clark's Cove Bay State G.G.	†2.39	†2.28	†2.17	2.53	†2.14	*2.06*	8.33	9.23	8.42	9.23	8.38	*8.*	1.98	1.84	2.08	1.98	1.65	*1.5*

*Potash in brands thus marked is largely if not entirely in sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

	Brand	Nitrogen						Available Phospho'c Acid						Potash					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
American Agricultural Chemical Co.'s	Clark's Cove King Philip...	1.37	1.23	1.33	1.33	1.26	*1.03*	8.18	8.09	8.94	8.06	8.38	*8.*	2.29	2.27	2.47	2.16	2.06	*2.*
	Clark's Cove Potato Fert...	†2.27	†2.21	†2.42	†2.39	†2.10	*2.06*	7.58	8.05	8.84	8.78	8.56	*8.*	3.23	3.34	3.54	3.18	3.50	*3.*
	Cleveland Fertilizer..........	1.44	1.33	1.33	1.23	1.37	*1.03*	8.14	8.54	8.44	8.38	8.78	*8.*	2.24	2.67	2.36	2.03	2.20	*2.*
	Cleveland Potato Phos......	†2.14	†2.07	†2.14	†2.10	†2.14	*2.06*	8.18	8.02	8.66	8.18	8.26	*8.*	3.32	3.00	3.12	3.85	3.21	*3.*
	Cleveland Superphosphate.	†2.10	†2.17	†2.14	†2.10	†2.17	*2.06*	8.33	8.49	9.02	8.06	8.08	*8.*	1.80	1.81	1.99	1.80	1.92	*1.5*
	Crocker's Am. Corn Phos...	†2.28	†2.39	†2.21	†2.07	†2.01	*2.06*	8.12	9.60	8.66	8.02	8.14	*8.*	1.75	1.86	2.01	1.92	2.25	*1.5*
	Crocker's N. Rival Am. Bo.	1.26	1.30	1.37	1.16	1.16	*1.03*	8.47	7.86	8.54	8.04	8.82	*8.*	2.22	2.14	2.44	1.95	2.05	*2.*
	Crocker's Pot., Hop & Tob.	†2.28	†2.49	†2.12	†2.10	†2.05	*2.06*	8.08	7.78	8.54	7.87	7.68	*8.*	3.28	3.94	3.12	3.78	3.22	*3.*
	Crocker's Potato Special....	†3.65	†3.68	†3.33	†3.30	†3.33	*3.3*	7.02	6.78	6.90	7.32	6.08	*6.*	11.20	10.07	10.45	9.84	10.44	*10.*
	Cumberland Guano..........	1.67	1.37	1.33	....	....	*1.03*	8.04	8.32	8.72	....	....	*8.*	2.48	2.22	2.28	....	....	*2.*
	Cumberland Potato Fert....	†2.14	†2.39	†2.24	†2.17	†1.95	*2.06*	8.33	8.13	8.72	7.74	8.66	*8.*	3.22	3.21	3.49	3.10	3.78	*3.*
	Cumberland Superphos.....	†2.21	†2.07	†2.10	†2.24	†2.14	*2.06*	8.27	8.05	8.36	8.00	7.98	*8.*	1.68	1.94	2.03	1.87	1.82	*1.5*
	Darling's Farm Favorite....	†2.28	†2.28	†2.12	†2.21	†2.05	*2.06*	8.17	7.64	8.88	8.12	7.96	*8.*	3.42	3.20	3.38	3.32	3.01	*3.*
	Great East. Garden Special	†3.26	†3.54	†3.65	†3.30	†3.65	*3.3*	8.93	8.93	7.79	8.00	8.18	*8.*	7.54	7.18	7.72	7.10	7.26	*7.*

*Potash in brands thus marked is largely if not entirely in sulphate, †Contained 0.20 percent or more of water soluble nitrogen, usually as in nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

	Brand	Nitrogen						Available Phospho'c Acid						Potash					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
American Agricultural Chemical Co.'s	**Great East.** General Fert...	1.30	0.95	1.09	1.09	1.44	*0.82*	8.20	7.80	8.06	8.08	7.70	*8.*	4.06	4.04	4.70	4.03	5.09	*4.*
	Great East. No. Corn Spec.	†2.24	†2.24	†2.14	†2.60	†2.21	*2.06*	8.15	8.02	8.42	8.60	8.40	*8.*	1.78	2.01	2.23	1.72	1.89	*1.5*
	Great East. Potato Manure	†2.39	†2.24	†2.14	†2.24	†2.17	*2.06*	8.35	8.05	8.78	8.18	8.20	*8.*	3.24	3.42	3.32	3.44	3.20	*3.*
	Pac. Gu. Co.'s Nobsque Gu.	1.40	1.09	1.40	1.30	1.37	*1.03*	8.45	7.70	8.32	8.15	8.74	*8.*	2.21	3.26	2.32	2.02	2.02	*2.*
	Pac. Gu. Co.'s Potato Spec.	†2.53	†2.42	†2.24	†2.39	†2.07	*2.06*	8.27	8.60	9.00	8.08	8.28	*8.*	3.48	3.34	3.40	3.02	3.22	*3.*
	Pac. Gu. Co.'s Sol. Pac. Gu.	†2.17	†2.24	†2.21	†2.56	†2.14	*2.06*	8.10	7.79	8.24	8.02	8.70	*8.*	1.80	2.05	2.14	1.62	1.98	*1.5*
	Quinnipiac Climax Phos....	1.47	1.40	1.40	1.26	1.37	*1.03*	8.54	7.95	8.26	7.84	8.84	*8.*	2.06	2.68	2.26	1.94	1.99	*2.*
	Quinnipiac Corn Manure...	†2.35	†2.39	†2.28	†2.24	†2.05	*2.06*	8.64	7.90	8.84	8.16	8.18	*8.*	1.82	1.70	2.19	1.80	2.08	*1.5*
	Quinnipiac Market Garden	†3.37	†3.44	†3.58	†4.07	†3.40	*3.3*	8.10	8.68	7.92	7.99	8.03	*8.*	6.93	7.21	8.18	7.84	6.96	*7.*
	Quinnipiac Potato Phos.....	†2.24	†2.35	†2.21	†2.21	†2.07	*2.06*	8.29	8.60	8.86	8.30	8.50	*8.*	3.08	3.56	3.51	3.12	3.28	*3.*
	Read's Farmers' Friend.....	†2.24	†2.49	†2.17	†2.24	†1.81	*2.06*	8.06	8.26	8.96	8.26	8.30	*8.*	3.00	4.21	3.40	3.30	3.62	*3.*
	Read's H. G. F.'s Friend...	†3.09	†3.51	†3.68	†3.72	†3.12	*3.3*	8.14	6.40	6.94	6.56	6.30	*6.*	10.14	10.52	11.42	11.27	10.47	*10.*
	Read's Leader Bl. and Bone	1.26	1.19	1.26	1.16	1.19	*0.82*	6.89	6.49	8.12	7.02	8.28	*7.*	1.16	1.58	1.34	1.39	1.32	*1.*
	Read's Prac. Potato Spec'l	1.05	0.98	1.16	1.26	1.51	*0.82*	4.55	6.46	7.68	6.99	7.24	*4.*	8.62	7.86	8.64	8.08	10.03	*8.*
	Read's Standard Superphos.	1.33	0.95	1.19	1.09	1.47	*0.82*	8.29	8.27	8.44	8.08	7.67	*8.*	4.09	4.00	4.06	4.09	5.07	*4.*
	Read's Sure Catch Fert......	......	......	......	......	......	......	10.37	10.94	10.74	10.88	10.06	*10.*	2.20	2.32	2.18	2.22	1.57	*2.*

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*Potash in brands thus marked is largely if not entirely in sulphate, †Contained 0.20 percent or more of water soluble nitrogen, usually as in nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

	Brand	Nitrogen						Available Phospho'c Acid						Potash					
		1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Am. Agricultural Chemical Co.'s	Tucker's Imperial all Crops	1.33	1.26	1.33	1.33	1.07	*1.03*	8.70	8.54	8.32	8.50	9.66	*8.*	2.14	2.26	2.52	2.30	2.22	*2.*
	Tucker's Imperial Corn......	1.33	1.05	1.33	1.26	0.88	*1.03*	8.69	7.40	8.28	8.16	9.56	*8.*	2.28	2.20	2.57	2.14	2.17	*2.*
	Tucker's Imperial Potato...	1.40	1.33	1.44	1.23	1.12	*1.03*	8.54	8.31	8.34	8.02	9.70	*8.*	2.20	2.16	2.68	2.09	2.31	*2.*
	W. & Cl. Am. Corn Phos...	†2.32	†2.21	†2.17	†2.60	†1.96	*2.06*	8.05	8.72	8.58	8.56	8.48	*8.*	1.80	1.85	1.73	2.04	1.79	*1.5*
	W. & Cl. Am. High Gr. Sp.	†3 35	†3.72	†3.58	†3.40	†3.44	*3.3*	8.71	8.70	8.11	8.28	8.01	*8.*	7.40	*7.75	7.18	7.03	7.26	*7.*
	W. & Cl. Am. Potato Man.	†2.32	†2.32	†2.14	†2.32	†2.10	*2.06*	8.15	7.95	9.18	8.08	8.16	*8.*	3.40	3.36	3.40	3.79	3.15	*3.*
	W. & Cl. Am. Potato Phos.	†2.91	†2.70	†2.53	†2.95	†2.74	*2.5*	7.51	8.02	6.18	7.40	7.28	*6.*	6.41	6.90	5.40	6.86	5.60	*5.*
	W. & Cl. Prolific Crop Pro.	1.23	1.51	1.26	1.12	1.37	*0.82*	7.22	7.46	6.12	8.20	8.14	*7.*	1.20	2.47	1.42	2.00	1.25	*1.*
	W. & Cl. Royal Bone Phos.	1.26	†1.16	1.33	1.26	1.33	*1.03*	8.76	7.80	8.90	8.42	8.80	*8.*	2.07	2.25	2.25	2.00	1.95	*2.*
	Bowker's Corn Phosphate..	†1.89	†1.79	†2.17	†2.00	†1.61	*1.65*	8.15	8.36	8.42	8 60	8.54	*8.*	2.24	2.15	2.58	2.32	2.15	*2.*
	Bowker's Hill and Drill....	†2.67	†2.63	†2.77	†2.60	†2.86	*2.47*	8.56	9.63	9.31	9.26	9.44	*9.*	2.10	2.15	2.56	2.17	2.68	*2.*
	Bowker's Market Garden...	†2.46	†2.56	†3.02	†2.60	†2.77	*2.47*	6.36	6.10	6.12	6.48	6.66	*6.*	9.78	10.90	10.79	10.04	9.85	*10.*
	Bowker's Potash Bone......	†1.05	1.05	1.40	1.12	1.12	*0.82*	6.27	6.08	8.76	8.10	8.76	*6*	2.26	2.41	2.12	2.12	1.93	*2.*
	Bowker's Potash or Staple.	†1.12	†1.05	1.23	1.19	†1.30	*0.83*	8.02	7.54	8.58	7.62	8.98	*8.*	3.26	2.93	3.54	3.24	3.58	*3.*
	Bowker's Pot. and Veg. F.	†2 49	†2.49	†2.56	†2.81	†2.32	*2.47*	8.55	8.17	9.06	9.44	8.42	*8.*	3.74	4.43	4.40	4.72	4.57	*4.*

*Potash in brands thus marked is largely if not entirely in sulphate, †Contained 0.20 percent or more of water soluble nitrogen, usually as in nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Bowker's Pot. and Veg. P.	1.79	1.82	†2.17	†1.89	†1.65	*1.65*	(a) 7.93	(a) 8.22	(a) 8.31	8.82	8.70	*8.*	2.40	2.11	2.48	2.31	2.19	*2.*
Bowker's Square Brand....	2.00	†2.10	†2.14	†1.96	†2.09	*1.65*	7.94	5.77	8.56	6.72	8.22	*6.*	2.22	2.48	2.55	2.64	2.33	*2.*
Bowker's Stkbdg. Corn M.	†3.65	†3.30	†3.79	†3.51	†3.55	*3.29*	9.80	10.28	9.26	9.02	8.28	*10.*	7.26	7.27	7.58	7.60	7.01	*7.*
Bowker's Stkbdg. Grass...	......	†......	......	†6.03	†4.91	*4.93*	......	......	......	6.06	4.44	*4.*	......	......	......	6.51	7.85	*6.*
Bowker's Stkbdg. Pot. M.	†3.91	3.47	†3.54	†3.33	†3.24	*3.29*	7.25	6.68	5.98	6.60	6.14	*6.*	9.96	10.06	9.94	10.10	10.27	*10.*
Bowker's Super with P't'sh	†......	......	......	......	......	......	......	......	......	11.40	9.93	*10.*	......	......	......	2.52	1.50	*1.*
Bowker's Sure Crop Phos..	1.02	†0.95	1.54	1.09	1.16	*0.82*	(a) 8.90	(a) 8.03	(a) 7.72	8.23	9.06	*8.*	2.08	2.00	2.50	1.95	2.02	*2.*
Bowker's Vt. Grange Ch..	†2.39	†2.28	†2.17	......	†2.17	*2.06*	8.71	9.16	8.84	......	8.02	*8.*	3.64	3.30	3.02	......	3.05	*3.*
Buff. F. Co. Celery & Pot..	......	......	......	......	†1.68	*1.64*	......	......	......	......	7.71	*8.*	*......	......	......	......	10.45	*10.*
Buff. F. Co. Farm. Choice..	†0.91	0.84	0.98	0.98	†1.09	*0.82*	9.81	8.38	8.13	6.28	8.48	*8.*	4.02	*5.98	*4.40	4.14	5.02	*5.*
Buff. F. Co. Fish Guano....	0.91	0.88	1.05	1.43	†1.26	*0.82*	(a) 9.13	(a) 9.87	9.14	6.76	9.28	*9.*	*2.06	*1.86	*2.54	3.14	3.25	*2.*
Buff. F. Co. General Crop..	......	......	......	......	......	......	......	10.35	8.90	9.20	10.77	*9.*	......	*1.68	*2.35	3.65	5.15	*3.*
Buff. F. Co. High Gr'd Man	†3.58	3.10	†2.71	......	......	*3.28*	8.91	8.56	7.18	......	......	*7.*	*8.08	*8.24	*8.66	......	......	*10.*
Buff. F. Co. Id. Wht. & Co.	1.33	1.44	1.68	1.51	1.93	*1.64*	10.17	10.96	8.71	7.60	8.52	*9.*	*3.99	*4.31	*5.00	5.06	4.59	*5.*
Burl. R. Co. Animal Brand	......	2.78	2.74	2.80	2.95	*2.*	......	(b) 4.81	(b) 4.66	(b) 6.44	5.32	*5.*	......	4.91	3.82	4.10	4.50	*5.*
Burl. R. Co. Spec. Potato..	......	......	......	2.91	2.95	*2.47*	......	......	......	6.76	5.06	*5.*	......	......	......	5.42	7.34	*6.*

*Potash in brands thus marked is largely if not entirely in sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(a) Available phosphoric acid guaranty, 9 percent. (b) Available phosphoric acid guaranty, 4 percent.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Coe-Mort. Corn and Potato.	1.79	1.66	1.46	......	1.26	*1.23*	10.20	8.95	8.70	......	8.06	*8.5*	*2.82	*3.03	*2.57	......	2.43	*2.5*
Coe-Mort. Gold Brand.......	†2.53	†2.17	†2.56	†2.00	†2.42	*2.4*	9.74	8.99	8.76	5.52	8.05	*8.*	*5.34	*4.64	*6.06	9.40	5.67	*6.*
Coe-Mort. H. G. A. B. Super	†2.39	†2.46	†2.14	......	2.03	*1.85*	(c) 10.28	(c) 9.67	(c) 9.00	.....	(c) 9.74	*8.*	*(c) 2.72	*(c) 2.90	*(c) 2.40	......	(c) 2.84	*3.*
Coe-Mort. New Eng. Corn...	1.33	1.33	1.05	0.91	†1.40	*0.8*	9.60	9.67	8.68	5.73	9.36	*7.5*	*3.04	*3.18	*3.01	*3.23	3.05	*3.*
Coe-Mort. New Eng. Potato	1.65	1.44	1.02	0.95	0.98	*0.8*	9.88	9.07	8.51	5.70	8.28	*7.5*	*3.08	*3.52	*3.31	*3.49	2.62	*3.*
Coe's Prize Br. Grass & Gr.	......	......	... ..	......	......	.....	9.90	9.53	11.50	......	11.18	*10.*	*2.26	2.18	*2.03	......	1.64	*2.*
Essex A 1 Superphos.........	......	......	......	......	1.14	*1.2*	......	......	......	......	8.42	7.	......	......	......	......	2.13	*2.*
Essex Comp. Corn, etc......	......	......	.....	......	†3.13	*3.28*	......	......	......	......	6.10	*6.*	......	......	......	......	10.44	*10.*
Essex Comp. Potatoes, etc..	......	......	......	......	†3.44	*3.25*	......	......	......	......	5.58	7.	......	......	......	......	10.80	*10.*
Essex Grass and Grain......	......	......	......	......	1.02	*0.82*	......	......	......	......	9.08	*8.*	......	.....	......	......	4.46	*4.*
Essex Mar. Garden & Pot..	......	......	......	......	1.98	*2.*	......	......	......	......	7.93	*8.*	......	......	......	......	5.55	*5.*
Essex XXX Fish & Pot....	......	......	......	......	2.10	*2.*	......	......	......	......	9.14	*8.*	......	......	......	......	3.04	*3.*
Lister's A. B. & Pot. No. 2	......	......	......	......	......	......	9.36	11.01	10.84	9.76	10.14	*10.*	2.60	2.25	2.21	2.01	2.17	*2.*
Lister's G. Brand.............	0.98	0.95	1.19	0.88	0.98	*0.82*	7.60	9.56	8.70	8.64	8.16	*8.*	4.40	3.73	4.02	4.03	3.94	*4.*
Lister's Grass and Oats......	......	......	1.05	......	0.95	*0.82*	......	......	8.18	......	8.05	*8.*	......	......	4.16	......	3.70	*4.*
Lister's Oneida Special......	1.42	0.95	0.91	0.98	0.98	*0.83*	8.13	7.11	7.04	7.70	7.34	7.	1.88	1.37	1.24	1.17	1.33	*1.*

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*Potash in brands thus marked is largely if not entirely in sulphate, †Contained 0.20 percent or more of water soluble nitrogen, usually as in nitrate of soda.

(c) Available phosphoric acid guaranty, 9 percent; potash guaranty, 2.25 percent.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
Lister's Potato Manure......	†3.18	†3.61	†3.51	†3.68	†3.61	*3.3*	9.28	8.74	8.48	9.28	8.75	*8.*	6.66	7.94	7.07	7.00	7.26	*7.*
Lister's Special Corn Fert..	†2.07	2.00	†1.75	1.82	1.79	*1.65*	8.51	8.78	8.62	8.42	8.55	*8.*	3.54	3.34	3.46	3.30	3.49	*3.*
Lister's Special Pot. Fert...	†2.24	2.00	†1.75	1.79	1.89	*1.65*	8.80	8.36	8.66	8.12	9.07	*8.*	3.24	3.23	3.13	3.18	3.35	*3.*
Lister's Special 10% Potato	......	1.86	†2.00	1.72	1.79	*1.65*	......	8.79	9.34	8.46	9.80	*8.*	......	11.62	10.01	7.97	10.41	*10.*
Lister's Success Fertilizer..	†1.82	1.40	1.40	1.40	1.30	*1.24*	9.28	9.38	10.02	9.08	9.42	*9.*	2.44	2.19	2.20	2.50	2.24	*2.*
Lowell (Swift's) Animal...	2.63	2.60	2.53	2.42	2.46	*2.47*	(d) 9.73	(d) 9.73	10.06	8.28	8.32	*8.*	4.02	4.06	4.18	4.35	4.15	*4.*
Lowell (Swift's) Bone Ft.	1.89	1.68	1.93	2.00	1.72	*1.64*	8.03	9.16	9.30	7.77	8.44	*8.*	3.12	3.43	3.24	3.24	3.26	*3.*
Lowell (Swift's) Cereal.. ...	......	1.09	0.95	1.16	1.02	*0.83*	......	7.72	6.52	7.84	7.32	*7.*	......	1.40	1.16	1.64	1.57	*1.*
Lowell (Swift's) Empress..	1.01	1.26	1.44	1.30	1.37	*1.23*	8.20	7.26	7.62	7.54	7.34	*7.*	2.60	2.50	2.09	2.01	2.23	*2.*
Lowell (Swift's) Pot. Man.	1.93	2.03	1.75	1.79	1.74	*1.64*	7.36	8.75	8.12	7.38	7.78	*7.*	*4.14	*3.94	4.34	3.02	4.08	*4.*
Lowell (Swift's) Pot. Phos.	†2.77	2.84	2.49	2.24	2.70	*2.46*	8.15	9.16	8.20	8.79	7.66	*8.*	*6.30	*6.00	6.28	*5.30	5.67	*6.*
Lowell (Swift's) Sterling...	......	0.98	0.98	0.84	1.02	*0.82*	......	8.23	8.66	7.84	8.21	*8.*	......	3.65	3.62	4.28	4.06	*4.*
Lowell (Swift's) Superior..	......	......	†3.96	†3.79	†3.86	*3.7*	......	......	8.76	7.40	7.60	*7.*	......	......	9.75	9.75	9.78	*10.*
N. E. F. Co., Corn & Grain	1.54	1.53	1.23	1.40	1.23	*1.23*	8.27	7.84	7.58	7.52	7.06	*7.*	2.56	2.45	2.20	1.88	2.06	*2.*
N. E. F. Co., Corn Phos......	1.75	1.86	1.89	1.82	1.84	*1.64*	8.03	7.98	9.62	7.76	8.00	*8.*	3.04	3.00	3.25	3.00	3.22	*3.*
N.E.F. Co., H.G. 10% Pot.	......	......	......	†3.79	3.81	*3.5*	......	......	......	7.00	7.04	*7.*	......	......	......	10.18	9.95	*10.*

*Potash in brands thus marked is largely if not entirely in sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(d) Available phosphoric acid guaranty, 9 percent.

ANALYSES OF LICENSED FERTILIZERS—1904-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar	1904	1905	1906	1907	1908	Guar
N. E. F. Co., Peerless........	......	....	......	......	0.98	*0.82*	......	......	......	......	6.89	7.	......	......	......	......	1.23	*1.*
N. E. F. Co., Potato Fert..	2.03	1.86	1.86	1.75	1.89	*1.64*	7.49	7.85	8.14	7.28	7.12	7.	*4.06	*4.13	*4.13	*3.47	4.06	*4.*
P. & P. Co.'s Grain Grower	......	......	1.12	1.33	1.47	*1.23*	......	......	8.02	6.66	7.32	7.	......	......	2.02	1.92	2.36	*2.*
P. & P. Co.'s Plym'h Rock	......	2.63	2.49	2.62	2.49	*2.47*	......	8.11	8.34	7.75	8.20	*8.*	......	4.08	4.11	3.86	4.32	*4.*
P. & P. Co.'s Potato Fert...	......	......	1.72	1.86	1.89	*1.65*	......	......	6.96	6.30	6.04	*6.*	......	......	6.87	7.44	4.16	*6.*
P. & P. Co.'s Pot. Grower..	......	......	......	......	†2.49	*2.46*	......	......	......	......	6.26	*6.*	......	7.34	......	......	9.69	*10.*
P. & P. Co.'s Star Brand...	......	1.64	1.75	1.65	2.24	*1.65*	......	6.91	7.02	7.28	7.16	7.	......	(e) 2.50	(e) 2.78	3.98	4.15	*4.*
R. & H. Co.'s Compl. Phos	......	† (f) 1.12	† (f) 1.47	† (f) 1.16	† (f) 1.12	*1.5*	......	(f) 9.61	(f) 8.86	(f) 8.04	(f) 8.42	7.	......	(f) 4.17	(f) 4.72	(f) 4.66	(f) 4.03	*5.*
R. & H. Co.'s Grass & Gr...	......	†2.46	2.81	3.33	3.05	*2.2*	......	8.39	8.06	6.03	7.12	*6.6*	......	12.00	12.66	14.43	10.83	*12.*
R. & H.Co.'s Oats & Top Dr.	......	†8.65	†8.54	†8.21	†8.70	*8.5*	......	(g) 4.69	(g) 5.48	(g) 4.25	(g) 4.83	*4.5*	......	10.00	8.02	9.80	10.29	*8.*
R. & H. Co.'s Potato Phos.	......	†2.07	†2.12	†2.35	†2.24	*2.*	......	9.79	8.40	9.82	8.82	*9.*	......	5.41	5.54	6.29	6.10	*5.*
R. & H. Co.'s Sol.Co.G'l Cp.	......	†3.12	†2.70	†2.35	†2.35	*2.5*	......	(h) 6.79	(h) 6.14	(h) 7.84	(h) 6.40	*5.5*	......	8.40	9.25	8.85	9.14	*8.*
R. & H. Co.'s Sol. Potato...	......	†5.57	†4.35	†4.53	†4.95	*5*	......	7.97	7.36	7.95	8.48	7.	......	*5.86	*7.38	*6.93	*6.50	*5.*
R. H. & Co.'s Sol. Tobacco	.....	......	†5.75	†5.30	†4.55	*5.*	......	......	8.88	9.82	8.04	7.	......	......	*9.61	*10.92	*14.46	*10.*

*Potash in brands thus marked is largely if not entirely in sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(e) Potash guaranty 2.5 percent. (f) Nitrogen guaranty, 1 percent; available phosphoric acid guaranty, 8 percent; potash guaranty, 3.5 percent. (g) Available phosphoric acid guaranty, 3.9 percent. (h) Available phosphoric acid guaranty, 6 percent.

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MAY 17 1909

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN NO. 141

APRIL, 1909.

Apple Culture in Vermont.

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BURLINGTON:
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1909.

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Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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[*] In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 141: APPLE CULTURE IN VERMONT

BY WM. STUART

I. INTRODUCTION

The increasing popularity of the apple both at home and abroad has served to create a considerable degree of rivalry among fruit growers as to which particular section can produce the best fruit and put it upon the market in the most attractive manner. This good natured contest has given a great impetus to the industry. The rivalry and impetus, however, is very largely confined to the fruit growers of the Pacific northwest. New England growers and especially Vermonters as a class are not as yet practising strictly up-to-date methods of apple culture. There are in Vermont, as in other New England States, a few successful growers who are producing a reasonably fine grade of fruit. As a rule, however, Vermont orchardists are not skillful in the grading and packing of the crop and largely on this account fail to realize the fancy prices which the Oregon and Washington state products bring on the eastern markets.

The Champlain valley is *par excellence* the most favored section for apple culture in Vermont. The Connecticut valley comes next, with possibly the Lake Memphremagog region and the Lamoille valley ranking third, followed by the interior and more elevated portions of the state, the so-called hill towns. There are few if any sections where some varieties may not be grown.

Vermont soils and climate are for the most part admirably adapted to apple culture. Her limestone and granitic soils, especially on the "west side," seems particularly fitted to the development of a thrifty, long lived tree, while her climatic conditions favor the production of a high quality, long keeping, and well colored fruit. The cold winters tend to repress insect pests and fungous diseases, which are less in evidence than elsewhere in this country.

II. EXTENT OF THE INDUSTRY

These superior advantages ought to induce extensive commercial orcharding. Indeed large orchards were planted in many sections prior to the civil war. Yet notwithstanding, commercial apple growing in Vermont has not kept pace with the development of this industry in other sections. Not one-tenth of the apples are produced that might easily and profitably be grown here. The Yearbook for 1907, published by the American Agriculturist, states that the Vermont apple crop from 1902 to 1906 was: 1902, 600,000 barrels; 1903, 430,000 barrels; 1904, 700,000 barrels; 1905, 350,000 barrels; 1906, 300,000 barrels; an average production for five years of 476,000 barrels.

The twelfth census furnishes data as to the number of apple trees and production per county for 1899. These figures are shown below together with a calculation of the average number of bushels per tree and the percentage yields per county:

County.	Number of trees.	Number of bushels.	Average bushels per tree.	Percentage yield of state.	Relative rank of counties.
Addison	110,303	45,801	.41	3.9	Windham
Bennington	96,885	154,908	1.60	13.2	Bennington
Caledonia	83,450	61,664	.74	5.2	Windsor
Chittenden	127,325	39,020	.31	3.3	Rutland
Essex	35,265	21,337	.61	1.8	Washington
Franklin	97,879	45,841	.47	3.9	Orleans
Grand Isle	67,221	30,970	.46	2.6	Caledonia
Lamoille	64,742	38,935	.60	3.3	Orange
Orange	152,486	55,356	.36	4.7	Addison
Orleans	92,553	62,253	.67	5.3	Franklin
Rutland	127,416	90,462	.71	7.7	Chittenden
Washington	131,794	83,828	.64	7.1	Lamoille
Windham	257,190	328,277	1.28	27.9	Grand Isle
Windsor	230,622	118,170	.51	10.0	Essex
Total	1,675,131	1,176,822*			

The three southern counties, Windham, Bennington and Windsor are credited by the twelfth census with half the apple production of the State; while Addison and Grand Isle, well

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*Approximately 400,000 barrels.

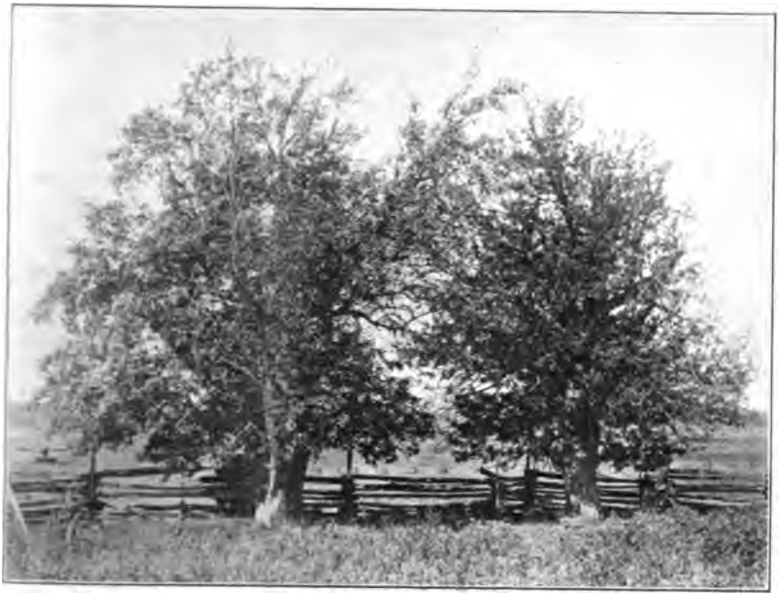

Figure 1. Old "seedling trees," the so-called "native fruit." These trees now growing in Addison County are thought to be almost 150 years old. (See page 69).

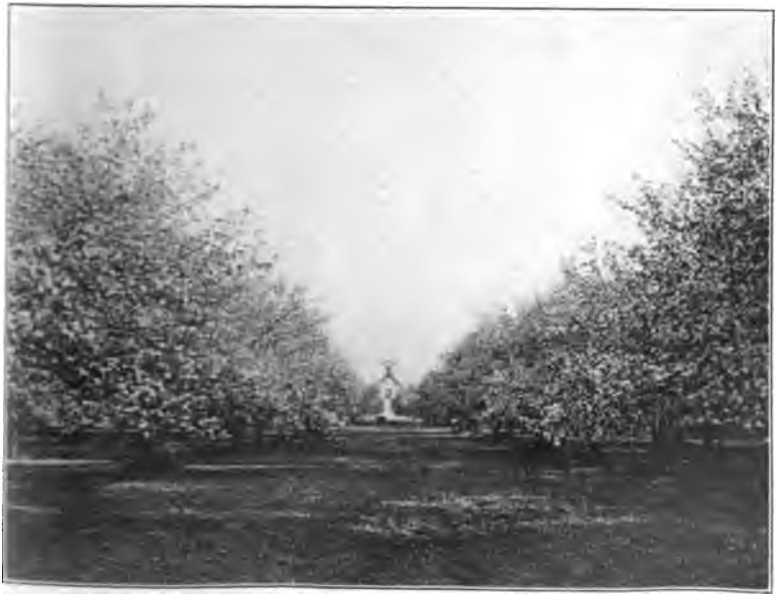

Figure 2. A modern apple orchard; well planned, well planted, well cared for, a source of wealth to its owner. Northern Spys and Rhode Island Greenings. (See pages 71-72).

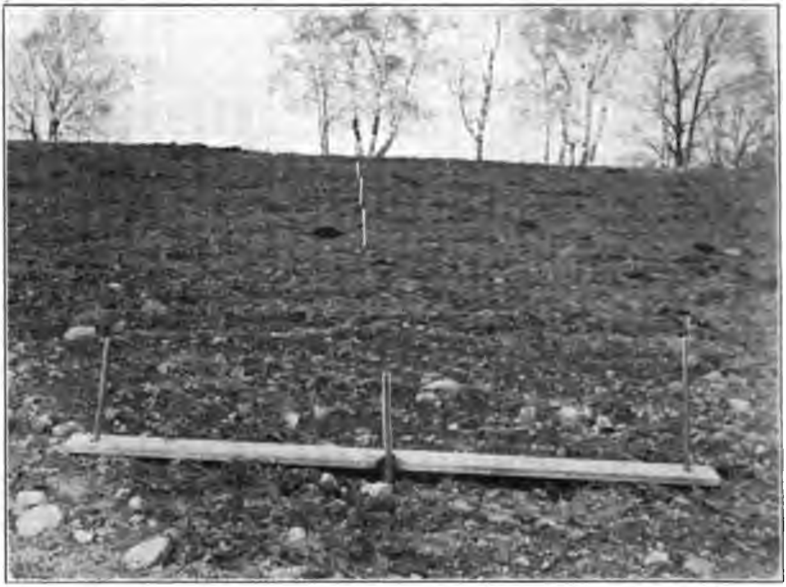

Figure 3. The use of the setting board. Note the tree stakes lined in the distance. See page 78 for description of use.

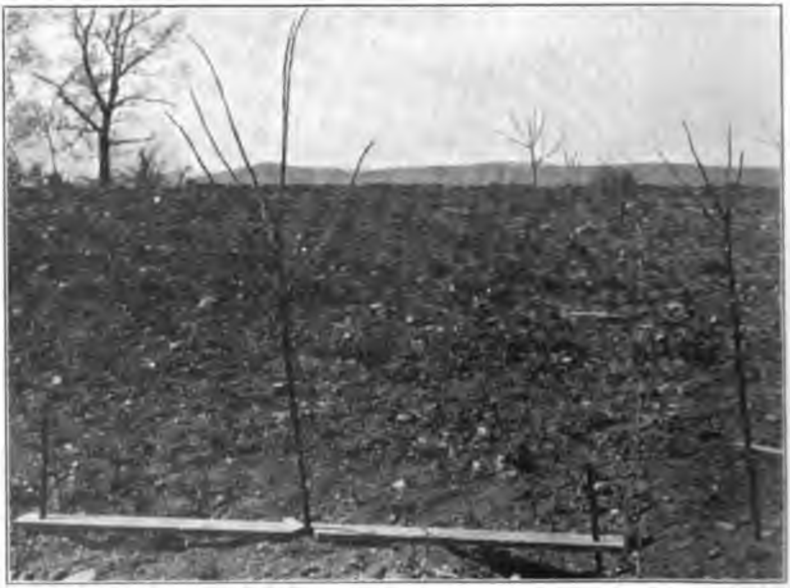

Figure 4. The use of the setting board. Note how, after the tree stake is removed and the hole dug, the tree can be exactly set in line. See pages 78 and 79. The tree at the extreme right is the same tree which occupies the center of the picture after it has been pruned. See pages 79 to 80.

known to be the banner apple growing counties, afford but 6.5 percent.

The writer has deemed these estimates and those exhibited by the American Agriculturist to be overstated and erroneous. In order to gain direct knowledge as to commercial orcharding, reports were sought and received from the several transportation companies[1] as to apple shipments for a series of years ranging from two to eight in number. These data compiled furnish the graphic chart exhibited on page 67 and a portion of the tabular matter shown in the next table.

STATISTICS OF SHIPMENTS BY COUNTIES

	Barrels.	Percent of total.
Addison	25,008	22.7
Bennington	2,804	2.5
Caledonia	541	0.5
Chittenden	18,081	16.4
Essex	21	0
Franklin	5,377	4.9
Grand Isle	22,134	20.1
Lamoille	325	0.3
Orange	4,322	3.9
Orleans	501	0.4
Rutland	4,562	4.1
Washington	1,439	1.3
Windham	11,139	10.1
Windsor	14,007	12.7
	110,261	100

According to the records of these several transportation companies, Addison county ships 23 percent, Grand Isle 20 percent, Chittenden 16 percent, Windsor 13 percent and Windham

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[1] The Station is indebted to the following gentlemen for information furnished as to shipments, D. A. Loomis, Gen. Mgr., Champlain Transportation Co.; C. E. Dewey, Gen. Fr't. Agt., Central Vermont Railway; Geo. Cassidy, Gen. Fr't. Agt., Rutland Railroad; Ira H. Shoemaker, Ind. Agt., Delaware & Hudson Railroad; C. D. Waters, Gen. Fr't. Agt., Montpelier & Wells River Railroad; C. A. Hayes, Gen. Fr't Agt., Grand Trunk Railway; W. K. Sanderson, Gen. Fr't. Agt., Maine Central Railroad; J. G. Porter, Gen. Mgr., Woodstock Railway Co.; R. Denio, Supt., Bristol Railroad; H. E. Mann, Auditor, Hoosac Tunnel & Wilmington Railroad; S. P. Howard, Gen. Fr't. Agt., Canadian Pacific Railway; T. A. Dugan, Gen. Fr't. Agt., Boston and Maine Railroad.

10 percent of the entire export, or 82 percent in all. Bennington county, which according to census data, grew more apples than Addison, Grand Isle and Chittenden counties combined, exported 3 percent against their 59 percent. If 476,000 (American Agriculturist) or 400,000 (twelfth census) barrels were grown and 110,000 exported, the average home consumption approximates nearly or quite a barrel per capita, a highly improbable assumption.

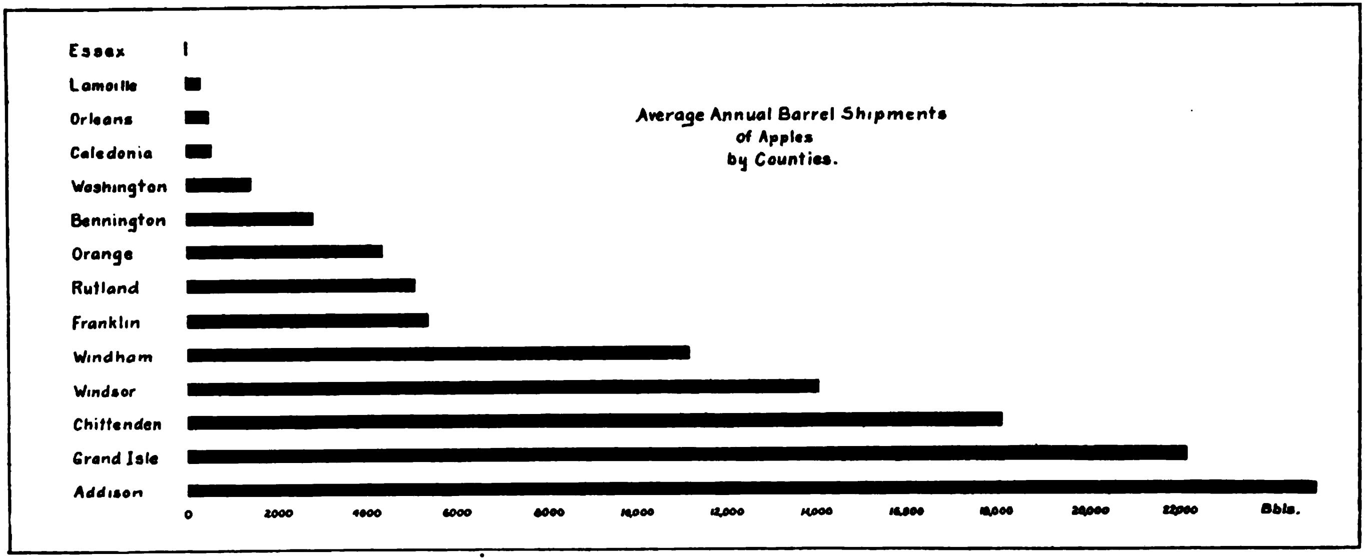
The better to compare the two sets of estimates they are arranged in the "deadly parallel column" herewith. The most casual inspection of the table reveals multitudinous incongruities and an utter lack of relationship. It should of course be understood that the figures obtained from the transportation companies represent shipments only. They are in other words an approximate index of the commercial orcharding of the state and of the various counties. They afford no clue, however, as to home consumption and hence do not indicate total crops.

COMPARISON OF CENSUS AND TRANSPORTATION DATA

County.	Number of bushels.		Percent.	
	Census.	Transportation.	Census.	Transportation.
Addison	45,801	75,024	3.9	22.7
Bennington	154,908	8,412	13.2	2.5
Caledonia	61,664	1,623	5.2	0.5
Chittenden	39,020	54,243	3.3	16.4
Essex	21,337	63	1.8	0.
Franklin	45,841	16,131	3.9	4.9
Grand Isle	30,970	66,402	2.6	20.1
Lamoille	38,935	975	3.3	0.3
Orange	55,356	12,966	4.7	3.9
Orleans	62,253	1,503	5.3	0.4
Rutland	90,462	13,686	7.7	4.1
Washington	83,828	4,317	7.1	1.3
Windham	328,277	33.417	27.9	10.1
Windsor	118,170	42,021	10.0	12.7

If credence is accorded the census data it follows that Chittenden growers ship 35 percent, Addison growers 63 percent and Grand Isle growers 220 percent more apples than they grow. On the other hand Bennington and Washington growers eat 19

SHOWING THE EXTENT OF COMMERCIAL ORCHARDING IN VERMONT AND THE LOCATION WHENCE SHIPMENTS ORIGINATE.



apples out of 20 grown, Caledonia growers 37 out of 38, Lamoille growers 39 out of 40, Orleans growers 41 out of 42, while the inhabitants of Essex county are such ardent advocates of the Apple League as to eat 299 out of 300 fruit and to ship by railroad but a beggarly 63 bushels from the 21,000 they grow. It is difficult to understand why the growers of Grand Isle, the apple paradise of New England, should deny themselves the privilege of eating a single apple and also import for the purpose of again exporting 220 percent of their crop. It is equally hard to comprehend why the Essex county farmers, hardly one of whom has ever to the writer's knowledge attended a State Horticultural Society meeting, or made an inquiry of the Station touching orcharding, should consume on the average annually nearly a barrel per capita, men, women and children.

Still further may be compared with the census data the statements in bulletins 55 and 89.

Grand Isle. Vermont station investigations in 1896—a year of tremendous cropping. Bearing trees 34,885; young trees 17,229; crop 40,424 barrels. 1899 census: trees 67,221; crop 10,323 barrels. The Vermont Station data were taken in a "very thorough investigation reaching personally to each farmer and apple grower in the county, and being checked by records of nearly all shipments from the county."

Addison. Vermont station investigations 1901. Bearing trees 26,580; average crop of 1900 and 1901, 20,765 barrels. 1899 census 110,303 trees; 15,267 barrels. The station data were obtained by an "employe, expert in such matters, going from farm to farm and making a census," the results of which were "extended and verified by correspondence and consultation with the best fruit men in all parts of the country."

Further calculations might be presented, using census data only, serving to cast yet more doubt upon the validity of the figures, but it seems unnecessary. Every Vermonter knows where Vermont apples are grown.

III. DEVELOPMENT OF THE INDUSTRY

Cider apple period.—Apple culture in Vermont, at least in its initial stages, did not differ materially from that obtaining in the earlier settled portions of the country. Seedling trees were planted and many varieties were developed most of which were of inferior quality. These were the days of the cider apple, and this stage of apple culture might appropriately be termed the "cider apple period." The many old seedling trees, or as they are more commonly termed, "native fruit," scattered here and there in the valleys and on the hillsides, are relics of this stage. Good types of this class of trees are shown in figure 1.

Commercial orcharding.—The second or commercial development period was brought about by the advent of the railroad, the influence of the Massachusetts Horticultural Society, and the dissemination of named varieties of fruit of superior merit. The effect of the two latter causes began to be felt early in the last century, and increased with the coming of the railroad in the forties. The interest shown in fruit culture in the Champlain valley at this time culminated in an informal convention of fruit growers held at St. Albans, October 4, 1850, at which time a resolution was passed recommending the organization of a horticultural society. As a result a convention was held in Burlington, February 11, 1851, at which time the Champlain Valley Horticultural Society was formed. Membership in this organization included not only Vermonters, but New York orchardists as well from across the lake. . The proceedings of this meeting were published in 1851 and shed much light upon the horticultural thought of that time. The Rev. Dr. John Wheeler of Burlington, then president of the University of Vermont, who was chosen president of the new-born organization, in his speech of acceptance, made pertinent allusion to the peculiar adaptability of this region to fruit growing, which seems well worth quoting. He said: "It might be further urged as a reason for the formation of this society and for the activity and energy of its members that it is located in the valley of Lake Champlain, a district of country possessing peculiarities sufficiently remarkable to require an organization for itself. We are in the vicinity of a large body of water with a strong tenacious soil, extending from the lake some twenty to sixty miles on either side to high mountains. The water tempers our climate and the different elevations of the land are equivalent to several degrees of latitude. For many kinds of fruit, particularly the apple, we have almost every variety of position and soil in which it flourishes, with general characteristic features of uniform excellence, that can scarcely be surpassed in any country and in any climate. Those who are familiar with the fruit in this region as compared with that produced on the Atlantic coast, or at the south or west of us, know, that for the choicest varieties of apples this region is unsurpassed. We may hope, therefore, that by the diffusion of a correct and practical knowledge on horticulture and particularly on pomology, this society may aid in making the valley of Lake Champlain one of the most successful fruit growing regions in the country.. We may thereby greatly increase the wealth and add to the comfort and enlarge the enjoyment of the whole population". The lapse of over half a century has not as yet witnessed the full realization of this prophesy. This society remained in existence and held its annual meetings in Burlington until the outbreak of the civil war. Its modern successor, the Vermont Horticultural Society, was organized in 1896 and has held annual meetings from that date.

Modern orcharding.—The modern development in Vermont may be said to be in its infancy. Up-to-date commercial apple culture as it is now understood, has but few disciples here, even in the Champlain valley. The plow and the harrow, the setting board and the cover crop, the pruning knife and the spray, the storage house and the refrigerator car; all these adjuncts to modern orcharding are too little used here. Yet they are main factors in the success of the Northwestern apple growers, and prime reasons why Oregon apples are selling in Vermont markets as these words are penned at five cents apiece, with Vermont apples almost an unknown quantity. There is good reason, however, for the belief that the dawn of a new era in fruit culture is at hand. The day of the small orchard and considerable collection of varieties must give place to the large orchard of not more than two or three varieties, which have been selected because of their adaptations to soil, climate and market. (See figure 2.)

IV. STARTING AN ORCHARD

The factors governing the successful development of vigorous, prolific apple trees are now much better understood than formerly. The underlying reasons are now well grasped for many current horticultural practises concerning which but a few years ago only the vaguest conceptions were held. The most important of these are site, soil, climate, tillage, fertilization, pruning and spraying.

Choice of site.—A northeastern or eastern exposure which is commonly suggested is less essential with the apple than with less hardy fruits. Almost any exposure other than a northern or western one on a steep slope will serve admirably. More attention should be paid to good air drainage than to slope; hence an apple orchard should be raised somewhat above the adjoining land at least on one side.

Due regard should be given to exposure to strong winds. Wind swept hillsides or knolls should be avoided, or, if such are chosen, wind breaks should be planted at once on the sides from which blow the strongest winds. White cedar, Norway spruce, hemlock or white pine make the most effective hedges. The tree rows should be set far enough away from the hedge to insure them against injury from shading or from robbery of plant food.

Choice of soil.—Generally speaking a gravelly loam or limestone soil is best adapted to apple culture. Light sandy or heavy clay soils should be avoided. Sandy loam soils, if possessing a retentive subsoil, favor earlier maturity and higher coloration of the fruit. In any case, whatever soil is selected, it should be well-drained and well supplied with plant food, and, if possible, should be tillable. A clover sod or a hoed crop such as corn or potatoes is usually considered a good precedent to a newly prepared orchard site. The preparation of the soil should begin with deep fall plowing, followed in the spring with as thorough a fitting as would be required for the growth of a good corn crop. Barnyard manures if used should be applied in the fall or winter and thoroughly incorporated with the soil in the spring preparation.

Choice of varieties.—This is an ever perplexing problem. The selection may vary according to whether the fruit to be grown is intended for home use or whether it is to be a strictly commercial orchard. Varietal adaptations to soil and climate deserve careful consideration. If a commercial orchard is to be planted, not over three or four varieties should be chosen, and two would no doubt be better.

A circular letter of inquiry sent to the apple growers of the State asking what varieties had proved most profitable as well as what varieties each recipient would plant to-day for commercial purposes, elicited replies from which the following tables have been constructed. While this statement represents the views of those from whom replies were received, it does not, in the case of some counties at least, include very many replies. Hence it should be regarded simply as an index to the present views of certain growers as to desirable varieties and not of necessity as an expression of the views of the writer.

MOST PROFITABLE VARIETIES OF APPLES

Addison county.—Rhode Island Greening, Northern Spy, Baldwin, Ben Davis, McIntosh.

Bennington county.—Rhode Island Greening, Baldwin, Northern Spy.

Caledonia county.—No report.

Chittenden county.—Northern Spy, Baldwin, Rhode Island Greening, McIntosh.

Essex county.—Red Astrachan, Brunswick, Wealthy.

Franklin county.—McIntosh, Fameuse, Tolman Sweet, Northern Spy, Blue Pearmain, Pound Sweet.

Grand Isle county.—Rhode Island Greening, Baldwin, Northern Spy, Fameuse, McIntosh.

Lamoille county.—McIntosh, Wolf River, Wealthy, Scott Winter, Fameuse, Alexander.

Orange county.—Northern Spy, Fameuse, McIntosh, Red Astrachan.

Orleans county.—Bethel, Wealthy, Oldenburg, Fameuse, McIntosh, Peach.

Rutland county.—Fameuse, Northern Spy, McIntosh, Rhode Island Greening.

Washington county.—Fameuse, King, McIntosh.

Windham county.—Baldwin, McIntosh, Red Astrachan, Twenty Ounce.

Windsor county.—Northern Spy, McIntosh, Rhode Island Greening, Baldwin, Ben Davis.

VARIETIES RECOMMENDED FOR PLANTING

Addison county.—Rhode Island Greening, Northern Spy, McIntosh, Baldwin, Fameuse, Ben Davis, Spitzenburg.

Bennington county.—Rhode Island Greening, Northern Spy, Baldwin, Fameuse, Wealthy, Gravenstein.

Caledonia county.—No report.

Chittenden county.—Northern Spy, Rhode Island Greening, Baldwin, McIntosh.

Essex county.—Red Astrachan, Wealthy, Bethel, Peach, Brunswick.

Franklin county.—McIntosh, Northern Spy, Pound Sweet, Fameuse, Tolman Sweet, Blue Pearmain, St. Lawrence, Red Astrachan.

Grand Isle county.—McIntosh, Northern Spy, Baldwin, Rhode Island Greening, Fameuse, Spitzenburg.

Lamoille county.—McIntosh, Wolf River, Fameuse, Scott Winter, Alexander, Russian Baldwin.

Orange county.—McIntosh, Northern Spy, Rhode Island Greening, Red Astrachan, King, Fameuse.

Orleans county.—Bethel, Ben Davis, McIntosh, King, Oldenburg, Wealthy, Peach, Yellow Transparent.

Rutland county.—McIntosh, Northern Spy, Fameuse, Sutton, Wealthy, Opalescent.

Washington county.—McIntosh, Fameuse, Northern Spy, King.

Windham county.—Baldwin, McIntosh, Banana, Wealthy, Wolf River, Rhode Island Greening, Twenty Ounce, Gravenstein, American Blush.

Windsor county.—Northern Spy, McIntosh, Baldwin, Rhode Island Greening, Ben Davis, Alexander, Gravenstein, Yellow Bellflower.

The Station has made at one time and another several publications touching apple culture in Vermont,[1] many of which are out of print. From these several bulletins the following statements pertinent to the particular matter now in hand,—variety choice,—are culled. "The favorite varieties grown (in Grand Isle) are Northern Spy, Rhode Island Greening, Baldwin, Fameuse, Tolman's Sweet, Pound Sweet, Golden Russet, Ben Davis, Yellow Belleflower and Arctic." "The best market varieties grown are Rhode Island Greening, Fameuse, Northern Spy, Ben Davis and Baldwin." "A long list of varieties were found growing (in Addison County), the most popular being Greening, Baldwin, Northern Spy and Fameuse." "Varieties recommended where hardiness is important are: (*Summer*) Yellow Transparent, Red Astrachan; (*Autumn*) Longfield, Oldenburg, Fameuse, McIntosh, Wealthy; (*Winter*) Scott Winter, Pewaukee, Arctic, Wagener.

"In the Champlain and Connecticut valleys, and the southern part of the state, the following varieties succeed: (*Summer*) Early Harvest, Primate; (*Autumn*) Porter, Oldenburg, Lowell, Gravenstein, Fameuse, McIntosh; (*Winter*) King, Spitzenburgh, Northern Spy, Rhode Island Greening, Baldwin, Arctic, Golden Russet, Hubbardston, Seek-on-further, Belleflower, Tolman's Sweet."

Purchase and handling of nursery stock.—The writer is often asked, "Where can I best buy fruit trees? Most would-be fruit growers seem to think that it is almost essential to secure trees from the same or a more northern latitude than that in which they are to be grown. The writer does not deem this to be as important in the purchase of apple trees as in the case of less hardy fruits; yet he does not of course recommend the purchase of trees from southern nurseries. It is always well, however, to deal directly with some reliable nurseryman rather than through the tree agent. Trees purchased of peripatetic agents are always more expensive and less likely to be true to name than those bought directly.

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[1] Apple growing in Grand Isle county, Bulletin 55 (1896); Hardy apples for cold climates, Bulletin 61 (1897); The home fruit garden, Bulletin 74, (1899); Apples of the Fameuse type, Bulletin 83 (1900); Apple growing in Addison county, Bulletin 90 (1901); 14th report, pp. 277-313 (1901).

All things considered, a two year old tree is usually the best, provided one buys from a distant nurseryman. Such a tree has not as yet established its top, at least not so permanently but that it can be readily changed to suit the grower's fancy. It suffers less shock from transplanting and is more easily handled than are older trees. Inferior stock should be shunned. It is poor economy to set such, the best being none too good. An orchard properly planted and cared for should last a lifetime and longer. Orders made well in advance of the time the trees are to be set are likely to receive better attention from the nurseryman and to ensure choicer stock.

Frequently when nursery stock is freighted long distances serious delays occur in transit. This is apt to result in the trees arriving somewhat dried out; and unless they are properly handled loss ensues. If the tree roots appear dried and the branches somewhat shrivelled they should be placed in water either in a trough, barrel or other receptacle for from 24 to 48 hours; or, what is perhaps still better, completely buried in a moist soil for a like period or until the wood has again become plump. In planting the trees should not be unnecessarily exposed to sun or wind, but should be protected with moist soil or burlap until planting time.

Choice of planting time.—For Vermont conditions the writer is inclined to recommend spring planting. In so doing, however, it is not intended to imply that fall planting is never advisable. If the land is thoroughly prepared and well ripened trees are available, they may be set in the fall quite as successfully as in the spring. The trees should not be dug from the nursery rows before the young wood is well ripened. Neither should the practise of stripping the leaves from unmatured trees in order to permit of early fall shipment be countenanced.

THE ORCHARD LAYOUT

Distance between trees.—Too close planting is one of the most serious hindrances to the successful production of high grade fruit. A large share of the apple orchards especially those set from fifteen to forty years ago suffer from this mistake, which deprives the trees of air and sunlight, two of the cheapest and most essential factors in successful fruit growing. The writer while making a partial fruit survey of Orleans and Franklin counties some three years ago saw many orchards in which the trees were planted from sixteen to twenty feet apart, the branches interlacing, forming a complete network over the whole orchard area, thereby restricting sun and air exposure to the top or floor-like array of branches. In other words, these trees planted twenty feet apart simply had an area of 400 square feet of exposure to sunlight and air. If instead of four trees with an area of 1600 square feet exposed to sun and air, but one tree grew which did not meet its neighbors by about two feet, this well developed tree would have over twice the area exposed to sun and air on top and side alike or somewhere in the vicinity of 3500 square feet; and in addition from twenty to twenty-five percent of the soil would be open to the sunlight.

Investigations at the New York Station[1] indicate that:

Trees set 30 x 30 feet gave a four year average of 186 bushels per acre.

Trees set 31 x 31 to 35 x 35 feet gave a four year average of 222 bushels per acre.

Trees set 36 x 36 to 40 x 40 feet gave a four year average of 229 bushels per acre.

Varieties attaining the size of Northern Spy, Rhode Island Greening and Baldwin should be set from thirty-five to forty feet apart each way. Some growers are even setting these varieties forty by fifty feet apart. McIntosh, Fameuse and similar sized trees may be planted from thirty-two to thirty-five feet apart. Yellow Transparent, Tetofsky and other similar upright growers may be planted somewhat closer. Distance determining factors other than that of variety are the character of the soil, the severity of the climate, and the closeness of pruning. A strong soil will of course cause a greater wood development and must be taken into account. The effect of pruning will be discussed later. (See figure 2).

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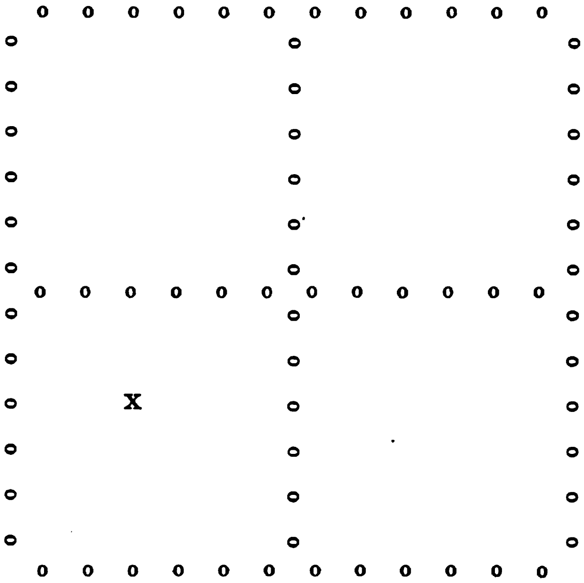
[1] New York (Cornell) Sta. Bul. 226, p. 301 (1905).

Systems of planting.—Having determined the number of trees to be planted and the distance apart they are to be set, the next step is that of "laying out the orchard" in such a way that the position of each tree is readily determined. One of the easiest methods known to the writer is that called the Yeoman system. This consists in running a base line on one side of the proposed orchard, setting stakes at desired intervals for tree rows. These stakes, however, instead of being set where a tree is to be planted, are set some ten to twenty feet beyond the last tree in the row. With the base line as a starting point, the orchard site is inclosed on its four sides with a row of stakes which are set at a similar distance from the last tree in the row to those of the base line. The stakes simply indicate the tree row in each direction. By running another set of stakes across the field and toward one end of it, in the opposite direction from that in which it is intended to furrow out, the field is ready for the plow. Using a heavy plow and a strong pair of horses and by going twice or more times in a furrow it is possible to furrow sufficiently deep so that little digging will be necessary for the reception of the tree roots. By running a line of stakes through the center of the field in each direction, each of which is in line with the tree row in but one direction (see chart on the next page) the field is ready for planting.



THE YEOMAN SYSTEM AS DESCRIBED ON PAGE 77.

Another method which is sometimes used, especially where the land is very uneven or where only a few trees are to be set, is that of locating the position of each tree by means of a small stake. The location of each individual stake may be accomplished by following the Yeoman system of running a line of stakes on all four sides, then sighting in each direction for the position of the tree stake. When each tree stake has been located the setting board is brought into play. This consists of a board some six feet in length and 4-5 inches wide, having two holes bored some 3 or 4 inches from either end and a notch in the center. The notch of the setting board is placed against the tree stake and two smaller stakes are set through the end holes, after which the board is removed (figure 3). The central stake is then removed and the hole dug. In setting the tree the setting board is again brought into play by being put over the two smaller stakes the center notch determining the position of the tree. (See figure 4). By being careful always to work in the same direction with the setting board and observing the same precaution while setting the tree, one should succeed in planting each tree in perfect alignment, in both directions, with every other tree in the row, without the necessity of sighting. This method of course cannot be recommended for large operations.

Planting the young trees.—Four men make an effective squad. One man prunes and distributes the trees. Another places the tree in proper position by sighting on the stakes in both directions, and compacts the soil around the roots of the trees as it is filled in by the two shovellers. Their duties are to remove whatever soil may be necessary for the reception of the tree roots and to shovel the soil back in around the tree. The surface soil should be placed in contact with the roots rather than the subsoil. Given a man who can sight accurately, the alignment of the trees in both directions will be close enough for all practical purposes.

The orchard chart.—The importance of making some permanent record of the position of each variety in the orchard cannot be overestimated. Having such a record, whether in the form of a chart or otherwise, the orchardist can remove the tree labels and thus avoid the frequent injury to trees due to girdling by the tree label fasteners. A simple record in which the tree in indicated by an X and the variety by a number will serve the purpose. Preferably such a record should precede the actual planting of the trees.

Pruning the young trees.—The successful growth of a vigorous and well developed tree is largely dependent upon rational methods of pruning. The pruning a tree receives during its first few years determines the shape of its mature head. The young tree at the time of setting should be severely pruned. As a rule the roots are cut back to six or eight inches and the top either to a whip, or, if it has been started at the right height in the nursery, from three to five of the best placed branches are selected for the scaffold limbs or framework of the head and these are cut back to correspond with the roots (see trees in figure 4). Fall planted trees should not be pruned back as severely, since the wood is likely to suffer more from drying out and winter freezing. Frequently when the top is light, pruning is deferred until spring, when practically the same cutting back is given as to the spring set trees. When the trees are pruned to a whip it is for the purpose of establishing a lower head or for securing better placed scaffold limbs. The limbs left for the framework of the tree should not be located opposite to each other as limbs thus placed would have a tendency to form a weak crotch. (For pruning of the mature tree see pages 86 and 87).

The advocates of the low headed apple tree seems to be in the ascendancy over those who prefer the high head. This type of tree is called for because of the necessity of fighting insect and fungous pests. The lower and more compact tree top makes spraying a much easier and simpler process, reduces the number of windfalls, and lessens the cost of harvesting. A low head might be defined as from 15 to 24 inches, and a medium head from 24 to 42 inches, while anything above 42 inches should be termed a high head.

V. CULTURE AND CARE OF AN ORCHARD

CULTURAL SYSTEMS

A half century ago orchard culture was practically confined to the grass system of management. Most orchard land was either held in grass or was rotatively plowed and sowed to grain, or was planted to hoed crops for a year or more and again seeded down. At the present time there are a number of systems which for convenience may be classified as follows: 1, Tillage. 2, Tillage with cover crops. 3, Tillage with intercropping. 4, Grass mulch. 5, Sod mulch. 6, Grass removal. 7, Pasture.

Tillage.—The tillage system pure and simple involves clean culture and the maintenance of a dust mulch throughout the growing season. This method is advocated where the rainfall during the growing season is comparatively light, necessitating the conservation of all possible soil moisture in order to insure a reasonably good tree growth. In such localities the humus

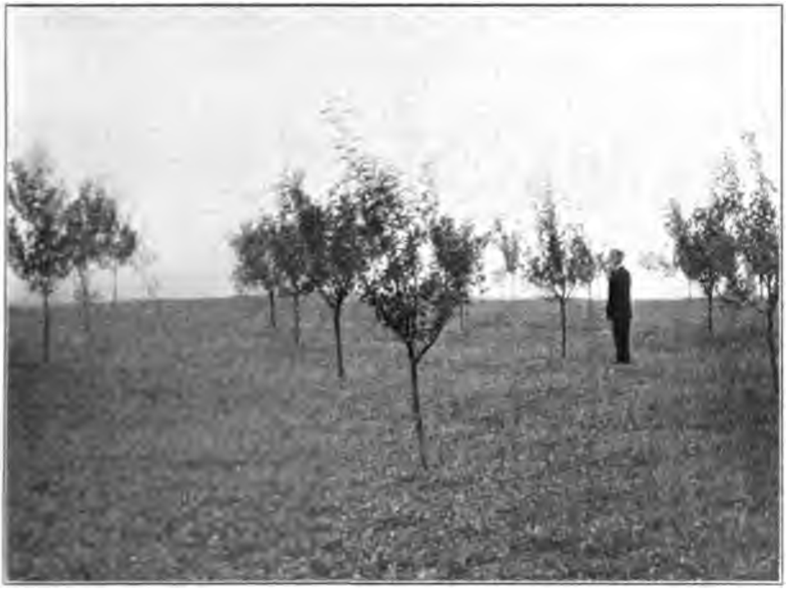


Figure 5. A cover crop of clover in a Vermont Station orchard, planted in July after tillage. The tillage saves the moisture for the trees; the clover gathers nitrogen and forms humus. (See page 81).

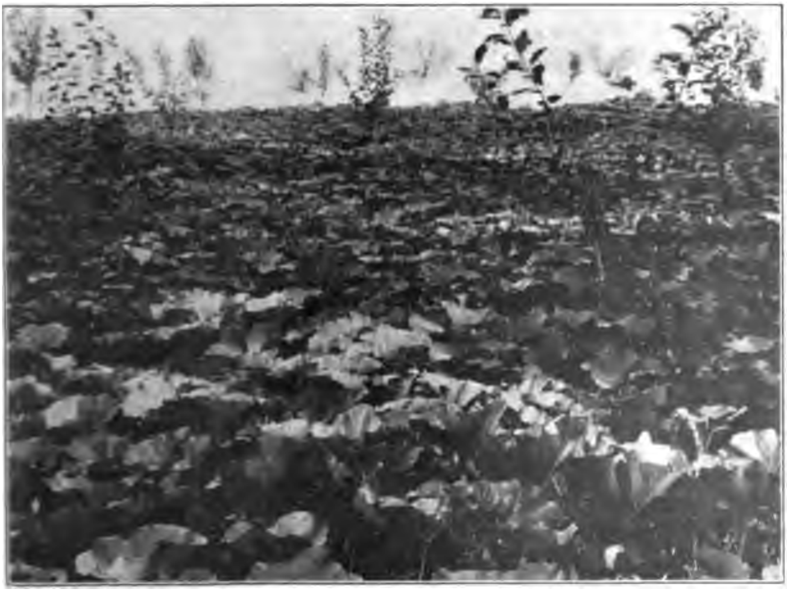
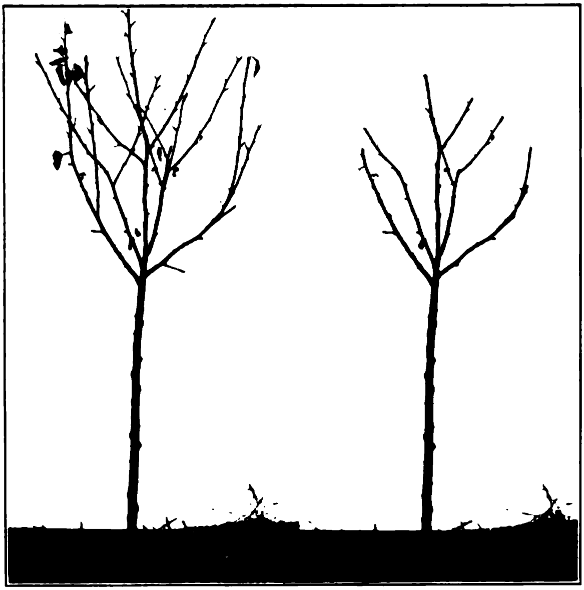


Figure 6. Tillage with intercrop. Squash planted in late June. Tillage maintained for a month after planting. Average returns for four years $75 per acre. (See page 82).



Before pruning. After pruning.

Figure 7. The pruning of the tree after it has been set in the orchard for one year. (See pages 86 and 87).

Figure 8. A shapely Northern Spy, systematically pruned, adequately fed, and properly sprayed. It is from such trees that the results shown in figure 11 are obtained.

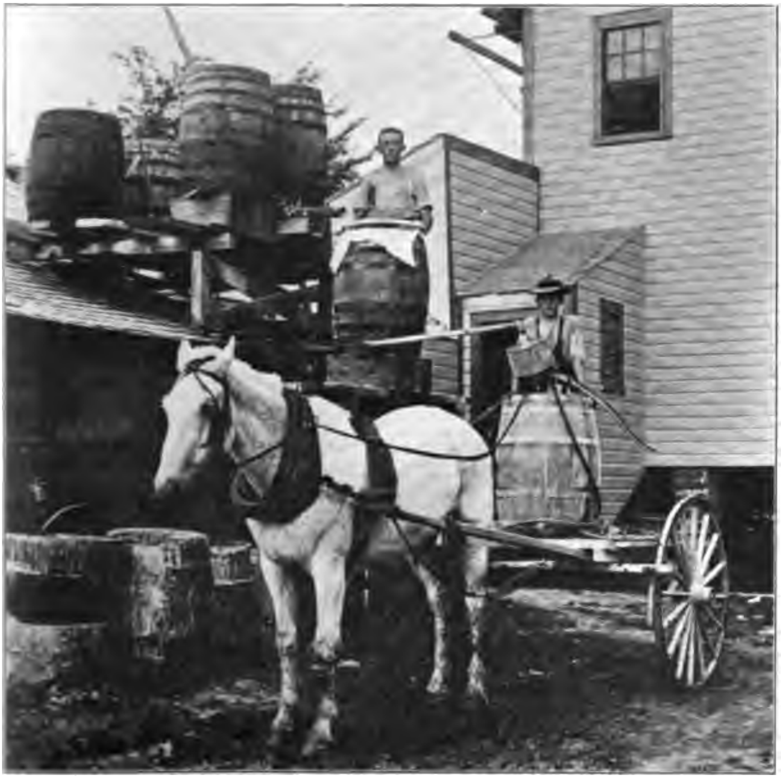
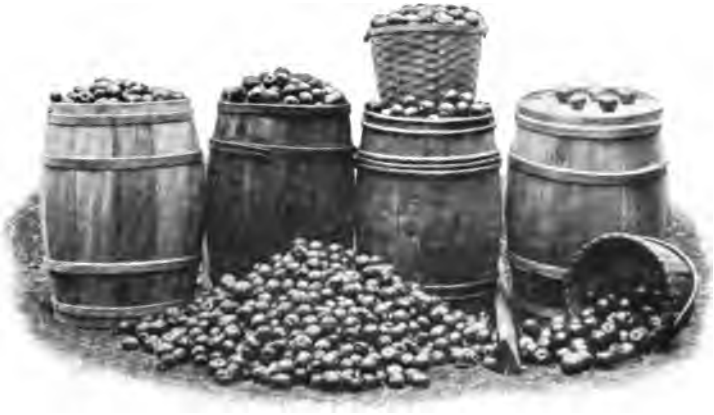


Figure 9. **The Station spraying outfit. Concentrated stock solutions of copper sulphate and lime are kept in the upper barrels; dilute ones are made therefrom using a hose in the second tier of barrels; and the bordeaux mixture is made in the Y shaped outlet by the mingling of the two solutions in transit as it falls upon and flows through the strainer into the lower barrel. The spray cart as pictured is rigged for potato spraying; but it may be readily made into a tree spray cart. See pages [illegible] and 91. See bulletins 111 and 113 for full description.**

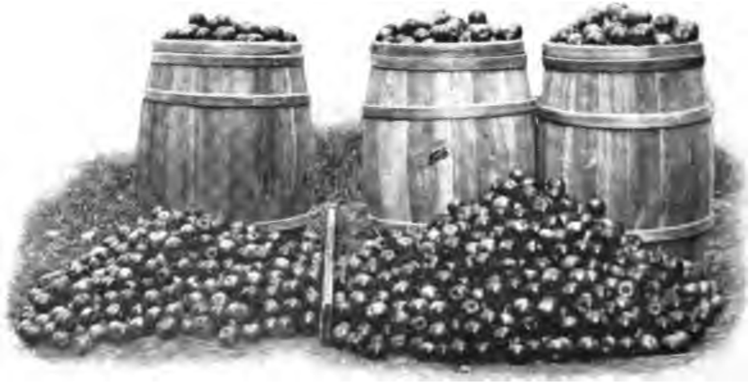


Cider apples (over 4 barrels).

No. 1 (5 apples).
No. 2 (½ bushel).

TREE I. NOT SPRAYED.

Figure 10. Every apple on this tree was spotted by the scab fungus and many of them were deformed and cracked. Even the 5 apples classed as No. 1 were scabby. The total value of this fruit was $2.15.



No. 2: 1½ barrels.

Selects: 2 barrels.
No. 1: 1 barrel.

TREE II. SPRAYED.

Figure 11. Scarcely a scab spot was found in the entire lot. The No. 2 fruit was so classified chiefly because of smaller size or of bruised spots. The total value of this fruit was $15.44.

SHOWING BENEFICIAL EFFECTS OF SPRAYING UPON THE QUALITY OF FAMEUSE APPLES IN 1897. THE TREES STOOD SIDE BY SIDE IN THE SAME ORCHARD.

content of the soil is maintained by applications of manure or straw. It is not an advisable system for Vermont conditions.

Tillage with cover crops.—The only difference between this system and the preceding one is that the dust mulch is maintained until about July 15, and then seeded down with some cover crop such as clover, vetch, oats, rye, buckwheat, etc. Several objects are thus accomplished. It serves to check too late growth of the trees; the cover crop furnishes humus to the soil; and if either clover or vetch is used serves to increase its nitrogen content. The choice of cover crops should be determined by the appearance of the trees. If the leaves are light green and the wood growth is scant, a deficiency of nitrogen is indicated and leguminous or nitrogen gathering crops should be used. If the leaves are dark green, the foliage luxuriant and the wood growth ample, non-leguminous plants should be grown. To secure a maximum benefit, these crops should not be removed but should remain as a winter protection and be turned under early in the spring to supply humus. (See figure 5).

Tillage with intercropping.—The system of tillage and intercropping is generally practised in the orchard before the trees arrive at a profitable bearing age, and after it has served its purpose is usually succeeded by tillage and cover crops. The growing of companion crops or intercrops in the young orchard affords the orchardist an opportunity, by careful management, to make such crops pay for the care and management of the orchard during the period elapsing between the time of setting the trees and the age of their profitable bearing. The kinds of crops which may be grown in the young orchard are only limited by the climatic and soil conditions. Generally speaking, however, they should be restricted to hoed crops. Vegetables and small fruits are the most desirable. The writer prefers vegetables because the orchardist can choose such crops as may be planted rather late and still mature a crop thus permitting early and unrestricted cultivation of the soil for a short time before planting, thereby furnishing moisture and plant food to the tree when it is making its most vigorous leaf and wood growth. Such crops as late cabbage, squash, cucumbers, beans, tomatoes, etc., may be used to good advantage. Corn and potatoes may be grown if not planted too close to the tree rows. Strawberries are preferred among fruits followed by the bush fruits,—currants, gooseberries, raspberries and blackberries. The objection to these crops is that their season of growth is practically identical with that of the apple tree, and that unless, as has been said, they are planted at some distance from the rows, they are apt to deprive the young trees of needed moisture and plant food. The successful practise of the intercropping system is wholly dependent upon the intelligence displayed by the orchardist in furnishing a sufficient amount of plant food to meet the extra demand made upon the soil by both tree and companion crop, as well as upon the intelligent selection of intercrops. For the past four seasons the writer has grown Hubbard squash upon certain portions of the young station orchard. The squash is usually planted about June 17-20 and as yet has not failed to mature a crop. This late planting permits of unrestricted cultivation of the orchard practically up to July 15 or later if desired, as the vines do not begin to run much before that date. The photograph, fig. 6, was taken about the middle of August and shows the ground well covered with vines. The returns from an intercrop will of course vary with the kind of crop grown, the care and fertilization, and the market. Owing to an almost total failure of the crop throughout New England the Hubbard squash intercrop grown in 1907 in the station orchard, returned about $150 per acre. The average receipts for four seasons have approximated $75 per acre. Of course such results are possible only where a good home market is available, and are not to be expected from shipments to larger markets where charges for freight and commission, as well as competition, serve very greatly to reduce the profits.

Grass mulch.—The grass mulch system of apple orchard management consists in the maintainance of an ample mulch of grass, straw or other coarse material beneath, and extending out beyond, the heads of the young trees. This mulch as advocated by Messrs. Vergon of Ohio and Grant Hitchings of New York, two of its foremost champions, should be of sufficient depth to prevent the growth of grass or weeds beneath it. The claims made for it are that it obviates the labor and expense of plowing and fitting the soil for the reception of the trees and all the subsequent cost of these operations. The trees are simply set in holes in the sod and are thereafter kept liberally mulched. The grass growing on the orchard area is at first quite ample for this purpose being cut once or twice during the season, raked up and piled beneath the trees. Other advantages claimed for this system are a slower, firmer wood growth, earlier formation of fruit spurs, and a more highly colored, firmer textured, better flavored and longer keeping fruitage. The main objection to the grass mulch is that the time finally arrives when the amount of mulch material produced in the orchard becomes insufficient and when it becomes necessary to secure it elsewhere. In other words, as the trees increase in size their demand for mulch increases, while the supply is continually decreasing. Eventually therefore the time arrives when the source of mulch supply must be located almost entirely outside the orchard. The question which will then confront the orchardist on land which can be tilled, is as to whether mulch can be produced at less expense than a tillage and cover crop system of management will cost.

Where the grass mulch system as thus outlined is literally practised from the time of planting, and where the orchard is located on a deep rich loam soil of a retentive character, good results may doubtless be secured. On rough, stony or hillside lands where tillage is difficult or impossible the grass mulch system may be recommended.

Sod mulch.—The sod mulch system differs from the grass mulch system in degree and method of mulch. At present there seems to be more or less confusion in the interpretation of the two systems, some writers using the term sod mulch to designate what others term grass mulch. The writer conceives the term sod mulch to be properly applied to the practise of cutting the grass growing upon the orchard land once or twice during the season and allowing it to remain where it falls. Such a system does not contemplate the bringing in of mulch material from other sources for the purpose of providing a more ample mulching of the ground beneath the trees. The two systems are quite different and should give distinctly diverse results in orchard practise.

A ten years' comparison of the merits of the sod mulch and the tillage and cover crop systems of orchard management was begun in western New York in 1904 by the New York station. No attempt was made to compare the grass mulch system (page 82); and the results obtained have no bearing upon the merits or demerits thereof; a statement which the comparison of terms just alluded to makes pertinent at this point.

The results obtained with two lots of mature trees favor tillage.

APPLE PRODUCTION: SOD MULCH VS. TILLAGE AND COVER CROP[1]

	118 trees Sod mulch	121 trees Tillage and cover crop
1904	615.1 barrels	591.9 barrels
1905	233. barrels	278.9 barrels
1906	210.3 barrels	531.1 barrels
1907	275.3 barrels	424.3 barrels
1908	325.3 barrels	722.5 barrels
Total for five years	1659. barrels	2548.7 barrels
Acre average	72.9 barrels	109.2 barrels

The tilled acre averaged 36.3 barrels more than did the sod mulch area, a gain of 50 percent. It took 434 apples grown on sod mulch to fill a barrel, while only 309 grown on the tilled area were needed. The one averaged 5.01 ounces in weight, the other 7.04 ounces. The tilled areas grew 9 percent more apples, in number, and they averaged to weigh 40 percent more.

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[1] New York (State) Sta. Bul. 314 (1909).

It cost on the average for the five years to handle the two plots: Sod mulch, $17.92 per acre; tillage and cover crop, $24.47. This $6.55 extra cost, however, shrinks into nothingness in comparison with 36.3 barrels more fruit, and the better grade of the entire 109 barrels. The cost of orchard management was 27 cents per barrel on sod mulch, 24 cents on tilled and cover crop; in other words it cost less per barrel to grow the better grade of fruit than it did to produce the poorer product.

The average growth of the branches were: sod mulch 3.4 inches, tillage and cover crop 6.7 inches. The color and volume of the foliage notably favored the tillage and cover crop system. The trend of the yields from 1904 to 1908 is downwards on the sod mulch and upwards on the tilled areas.

These are very striking results. They are doubtless valid for western New York conditions; and it is safe to say that the tillage and cover crop system should be practised in Vermont wherever conditions admit of adequate tillage operations.

Grass removal.—This system is commonly called the "sod" or "sod grass" method. The writer deems "grass removal" a more descriptive term for it contemplates the entire removal of the hay crop. The owner hays the orchard and if perchance the trees appropriate enough plant food to grow a crop of apples it is so much clear gain. Such a procedure does not tend to grow vigorous, healthy, productive trees and should be discarded. It has less merit than any system now in vogue save perhaps that of intercropping with cereals for harvest.

Sod pasture.—The practise of pasturing the orchard, while not to be recommended if one expects to secure maximum returns of fruit, may under certain conditions serve a useful purpose. In sections where the apple maggot or curculio is abundant, pasturing the orchard with hogs or sheep tends materially to lessen their ravages. Hogs and sheep injure the orchard less than do cattle or horses, as they do little browsing upon the tree and unfallen fruit, whereas the depredations of cows and horses are quite serious. As a general rule, however, orchard pasturing should be discouraged.

PRUNING

Pruning is perhaps the least understood of all orchard practises. Great damage may be thus done by the ill-informed orchardist. Yet on the other hand, by the judicious and intelligent use of the pruning knife, and occasionally of the saw, the tree top can be shaped almost as one wishes. Moreover if a wise selection of scaffold limbs has been made at the outset (see figure 4), subsequent pruning is very much simplified.

The objects of pruning are four: First, to develop a proper framework of limbs; second, to admit light and air to the center of the tree; third, to restrict a too rampant wood growth and thus to favor the development of fruit buds; and fourth, to remove all dead, decaying or fungus infected branches. No set rules can be given, for pruning is really nothing but a succession of judgments. Each tree must be pruned with respect to its own individuality. Many people confuse pruning with trimming. The writer has seen tree owners trim off all the short fruit spurs on the lower portion of the limbs, thus restricting the fruit bearing area to the outer ends of the branches. Is it any wonder that orcharding under such conditions is not a source of profit?

Pruning should begin with the placing of the tree as set forth on page 79; and should be continued throughout its life. In cutting back these branches some attention should be paid to the position of the uppermost bud to which the branch is pruned, as the direction of the branches can be very largely determined in this way. Varieties having a spreading habit of growth like the Rhode Island Greening may be given an ascending direction by pruning the branches to an inner rather than an outer bud. An upright grower like the Yellow Transparent should be pruned back to an outwardly placed bud. Observance of these details greatly assists in the formation of desirable tree tops. As the years progress from a third to two-thirds of the previous season's growth should be cut back and unnecessary branches be thinned out until the tree begins to bear heavily, when excessive wood production will cease. Pruning from this point onwards should be directed primarily to keeping the head sufficiently open to admit sunlight and air and to removing dead or fungus infected branches. (See figure 7).

Systematic pruning is one of the keys to successful fruit growing. If one can secure as shapely mature trees as is the Northern Spy tree shown in figure 8 or the rows shown in figure 2 he need have no fear, if proper cultural care is given, but that he will pick an abundant harvest.

FERTILIZATION

As a rule too little attention is paid to the proper fertilization of the orchard. The owner for the most part allows the trees to do their own foraging for plant food. In a good strong limestone soil, the apple tree may succeed fairly well for a considerable period without application of commercial or barnyard manures, provided no other crops are removed from the soil. If, however, the best results are to be obtained from the trees, it is highly essential that they should receive the same fertilization as that given to other farm crops. In brief, the apple crop should be regarded as is any other crop and it should be fertilized accordingly. A soil which is abundantly supplied with humus may contain sufficient plant food for the needs of the newly set trees for the first few years of their growth, especially if the tillage and cover crop or the grass mulch system is practised. It will generally pay, however, even in such cases to apply small quantities of either commercial or barnyard manure to the young trees. The essential object should be to secure a strong vigorous growth of well ripened wood each season. The application of large quantities of readily available nitrogenous manures should be avoided as it tends to encourage too soft and and too late wood growth, both of which are undesirable in orchard trees.

It is stated concerning the fertilization of orchard fruits in general and of apples in particular in bulletin 116 which deals with the fertilization of all sorts of crops that:

"The practice of orcharding involves continuous cropping, growing the tree for years and then growing fruit and tree at the same time. The long life of trees enable them to use relatively slow forms of plant food, but the great draft which large crops make calls for specific feeding at specific times to meet the large demand. During the growing period of trees nitrogen is particularly drawn upon; yet excess may force wood growth too late in the fall so that it does not "harden off" but winter kills. Later in the tree life soluble nitrogen tends to hinder fruit ripening.

Voorhees suggests for fruit trees in general two basic formulas: (a) equal parts by weight of ground bone, acid phosphate and muriate of potash; (b) one and a half parts of ground bone to one of muriate of potash. These would furnish on the 100-pound basis:

FORMULA 69 (VOORHEES) FOR FRUIT TREES IN GENERAL

Ingredients.	Weight.	Nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Potash.
Raw ground bone	100	3	23	8	..
Acid phosphate	100	..	15	14	..
Muriate of potash	100	..	..	..	50
Totals	300	3	38	22	50
Percentage composition		1.	13.7	7.3	16.7

FORMULA 70 (VOORHEES) FOR FRUIT TREES IN GENERAL

Ingredients.	Weight.	Nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Potash.
Raw ground bone	150	5	34	11	..
Muriate of potash	100	..	..	..	50
Totals	250	5	34	11	50
Percentage composition ...		2.	13.6	4.4	20.

(a) APPLES AND PEARS

On poor and light soils the feeding of the trees should begin at once; on those of better grade it may not begin when the orchard is set out. At the outset on poor soils considerable nitrogen is needed, which should be of the slow type. Tankage, the rather inert and hence cheaper forms of nitrogenous crude stock, or green manuring with legumes may be resorted to. If the latter practice is employed the crop should be turned under early lest it do more harm than good. Artificial feeding on good orchard soils may commence when the trees begin to bear.

Van Slyke suggests two formulas as alternatives, the amounts used increasing as the trees grow older:

FORMULA 71 (VAN SLYKE)

Ingredients.	Weight.	Nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Potash.
Nitrate of soda	25-50	4-8	....	....	....
Dried blood	40-80	5-9	....	....	....
Acid phosphate	200-400	..	30-60	28-56	....
Muriate of potash*	100-200	..	....	....	50-100
Totals	365-730	9-17	30-60	28-56	50-100
Percentage composition		2.5	8.1	7.8	13.9

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*Or one-half to one ton wood ashes.

FORMULA 72 (VAN SLYKE)

Ingredients.	Weight.	Nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Potash.
Cottonseed meal	100	7	..	..	..
Raw ground bone	100	3	22	7	..
Acid phosphate	100	..	15	14	..
Muriate of potash	100	..	..	..	50
Totals	400	10	37	21	50
Percentage composition		2.5	9.3	5.3	12.5

Voorhees suggests that either Nos. 69 or 70, 400 pounds to an acre, may be used on good soils when trees begin to bear, these amounts increasing as the years go on; that on medium soils the fertilization should begin earlier, and on poor soils that formula 70 should be used and should be fortified. He further states that 1000-1500 pounds annually used with mature trees have been found to pay, enhancing quality, augmenting quantity, and promoting longevity. Early spring applications, plowed in, are advised."

The grower should be largely governed in the matter of applying fertilizers to the orchard by the appearance of his trees. A knowledge of the functions of nitrogen, phosphoric acid and potash are essential aids to a proper understanding of the tree's needs. Nitrogen favors leaf, wood, and fruit growth; phosphoric acid, wood, fruit and leaf bud formation; potash, color, quality, and flavor of fruit, as well as working more or less in conjunction with phosphoric acid in fruit and leaf bud formation. If the color of the foliage is light and wood growth is restricted, it is an indication that the tree needs nitrogen. If leaf and wood growth is good and the tree does not form fruit buds abundantly, a lack of phosphoric acid is indicated. If the fruit is light colored, and the quality and flavor are poor, it signifies that either potash is needed or that an excess of nitrogen is available. The latter case i. e. the presence of excessive nitrogen, may be determined by the appearance of the foliage, amount of wood growth, and size of fruit.

SPRAYING

Spraying for fungous and insect pests is a necessary adjunct to successful fruit growing. Its practise by Vermont orchardists, though comparatively limited at present, is on the increase.

Spray equipment.—Success in the use of spray materials is largely dependent upon the degree of intelligence with which they are prepared and applied, and upon the spray equipment used. The essential requisites are a spray pump capable of developing sufficient pressure to throw a very fine spray, and suitable spray nozzles. Pressures of 200 pounds per square inch are now thought to be none too great for effective work. Such pressures can only be developed by strong pumps mechanically operated by gasolene or steam engines, or by geared wheel or axle attachments, or by gas pressure. Fairly effective work may of course be secured from well constructed barrel force pumps properly operated. Good spray nozzles are also needed. The Vermorel type of nozzles, including the Mistry, Demorel, Deming and others, is the most satisfactory one to use when combating fungous diseases of the apple, as they deliver under proper pressure an exceeding fine misty spray. A nozzle of the bordeaux type throwing a coarser spray with proportionately greater force and penetration is now preferred by many of the western growers in combating insect pests such as the codling moth. It has been demonstrated that the more effectively the arsenical spray liquid can be driven into the calyx end of the fruit the more destructive it is to the larvae of the codling moth.

Mixing outfits.—The labor involved in spraying may be materially reduced by providing a convenient mixing device. In the construction of such an outfit the orchardist should aim to save all needless lifting of materials in making and in filling his spray barrel or tank. This can often be accomplished by erecting a suitable platform convenient to the water supply on which the spray mixing barrels or tanks may be placed and into which water may be pumped or carried where water under pressure is available. Almost no lifting is necessary in making the spray material with such an outfit, and the spray barrel or tank may be filled by gravity. For suggestions concerning such an outfit see figure 9 in the center of this bulletin, and described at length in bulletins 111 and 113 and in the seventeenth report.

Fungicidal compounds.—Of the various compounds possessing fungicidal value, those containing copper and sulphur are distinctly superior. Bordeaux mixture, which is essentially a finely subdivided copper hydrate held in suspension in water, is now widely known and used. The formula most commonly employed is the 1-10 formula, one pound of lime, one pound of copper sulphate to ten gallons of water. These proportions may vary from 1-8 to 1-20 depending on the class of plants sprayed and the time of application. Sulphur and lime, known as the lime sulphur mixture, may be employed as an apple tree fungicide and has the distinct advantage of being a good scale insecticide as well. (See bulletin 113 on spraying.)

Insecticidal compounds.—Owing to the great diversity of the attacks by insects, naturally and necessarily a much greater variety of insecticidal compounds are in use. Arsenical poisons are used against leaf eating insects, contact insecticides against sucking insects, and repellants against wood-boring pests. Paris green and arsenate of lead are the most common arsenicals employed; lime-sulphur, whale-oil soap and tobacco preparations are used to kill by contact; while repellants consist for the most part of coal tar products such as carbolic acid which are used as washes. (See bulletin 113.)

FUNGOUS AND INSECT PESTS

Fungous pests.—The apple scab is the worst fungous disease in Vermont. Others of minor importance are blight and apple canker.

Insect pests.—The fruit infesting insects are in the order of their importance; the codling moth, apple maggot, and the apple and plum curculio. Those attacking the foliage, or leaf eating insects, are the apple and forest tent caterpillars, yellow-necked and red-humped apple tree worms, spring and fall canker worms. Of the sucking insects there are the apple leaf aphis, wooly aphis of the tree and roots, and the oyster-shell scale. The wood eating insects are represented by the round headed apple tree borer.

Fungous remedies.—Injury from the apple scab fungus may be largely prevented by the intelligent application of bordeaux mixture. The first spraying should be done before the buds have begun to unfold, the second just after the blossoms fall and a third some two weeks later. Subsequent sprayings are determined by seasonal conditions and the prevalence of the disease. (See results as shown in figures 10 and 11). Apple blight rarely injures apple trees in Vermont. This malady is caused by the bacterial organism which produces pear blight. The only satisfactory remedy is to cut out and burn all infected twigs. Apple canker is more or less common in Vermont orchards but rarely causes material loss. It is generally found in old and neglected orchards. Canker is caused by a fungous disease which usually gains entrance to the plant tissues through some external injury to the bark of the tree. Infected branches should, where possible, be removed and destroyed. Spraying with bordeaux prevents new infections.

Insect remedies.—The codling moth, which is by far the worst apple pest in Vermont, may be quite effectively combated by thorough spraying with some arsenical poison just after the blossoms fall. Arsenate of lead used at the rate of two pounds to fifty gallons of water is giving better satisfaction than paris green because it adheres better and does not injure the foliage. The moth emerges early in June and the female soon begins to lay its eggs. These are not, as has been commonly supposed, deposited upon the fruit, but largely on the under side of the leaves. Sanderson, Headlee and Brooks[1] state that about nineteen twentieths of the eggs were deposited upon the leaves, the balance being upon the bark and fruit. The earliest deposited eggs hatch in about ten days while the later ones only take about half as long. As soon as the larva hatches, it begins to migrate toward the fruit, and having reached it usually enters at the point of least resistance, which in its immature stage of development is through the calyx opening. A knowledge of the life history of this pest enables the orchardist to spray his trees intelligently. He knows that the weak point of resistance is in the calyx or blow end of the fruit. Here then is the point of attack. If he can fill the calyx end of each apple upon the tree with a poisonous spray, the most of the larvae will be destroyed before they have an opportunity to gain access to the interior structure of the apple. Hence he should spray within the first week or ten days after the blossoms fall, or before the calyx closes up and the apple begins to point downward. The nozzle used should throw the liquid with some force, for this reason a Bordeaux nozzle is preferred to a Vermorel to drive the spray liquid into the calyx end of each apple. One thorough spraying at this time has been found to give over 90 percent of worm free apples. A second spraying some three to four weeks later is recommended. The first spraying for codling moth can be combined with the second for apple scab, by adding the arsenical poison to the bordeaux mixture.

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[1] New Hampshire Sta. Bul. 131, pp. 22-24 (1907).

The curculio and apple maggot are much more difficult pests to combat. Frequent and thorough sprayings by the Illinois station has demonstrated the possibility of very largely controlling the injury caused by the apple and plum curculio.[1] Four sprayings served to decrease the number of injured fruit 69 percent and to increase the yield 54 percent over unsprayed plots. Eight sprayings decreased the injured fruit 80 and increased the yield 40 percent. Tillage and sunlight are two effective aids in the suppression of the curculio, as is also the destruction of all fallen fruit.

There is no known remedy for the apple maggot. Preventive measures such as the destruction of all fallen fruit are the only means of suppression that can be employed. Of course good tillage and judicious pruning and spraying materially aid in lessening the injury to the fruit. Arsenical poisons are not effective. Of the leaf eating insects mentioned, none as a rule may be called serious pests except in occasional seasons when they may be abundant. All are amenable to treatment by arsenical sprays. Paris green, arsenate of lead, arsenite of lead or other arsenicals may be used.

The sucking insects are best combated by spraying with contact insecticides. Kerosene emulsion, soap solutions or tobacco infusions for the apple leaf aphis, the wooly aphis, and the oyster shell scale may be used. The latter should be attacked when the young are moving about or have not as yet secreted a scaly covering. The oyster shell scale is far too abundant in the orchards of the Champlain valley and undoubtedly, when present in large numbers, materially lessens the vigor of the trees.

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[1] Ill. Sta. Bul. 108, p. 270 (1906).

There is no effective remedy for wood infesting insects like the round-headed apple tree borer. The orchardist may adopt certain protective measures such as exclusion or repulsion. The mature beetle may be prevented from depositing its eggs by wrapping the lower portion of the tree trunk with tar paper, building paper, or veneering. In placing confidence in such a preventive measure there is always danger that the beetle may find some opening into which she can thrust her eggs and before one realizes it the tree is infested with borers. Exclusion methods are only effective when they actually do exclude.

Repellants are also preventives, certain ill-smelling or caustic compounds being applied as a wash to the trunks of the trees. Most of the washes are of an alkaline nature consisting of soaps, or lyes to which carbolic acid is frequently added to give it an offensive odor. Many commercial washes have at various times been put upon the market, the use of which it was claimed would secure immunity from the borer. Experimental tests of these proprietary washes have usually shown them to be harmful to the bark of the tree, in many instances the injury being so great as to kill the tree.

The safest and most effective method, all things considered, is that of going over the young orchard trees twice each season examining each tree carefully for the presence of borers. When detected they should be at once removed with a sharp knife. The process of digging out a first season borer is a comparatively simple and easy process as they are just beneath the bark; the second season, however, they begin to tunnel deeper into the tree and by the third season have penetrated almost if not quite to the heart wood. To remove a second or third year larva it is necessary to make use of a stiff, somewhat flexible wire. After removing the castings from the tunnel opening, the wire is pushed upwards or downwards in the tunnel, as the case may be, until the borer is encountered; in this way much cutting and consequently much injury to the tree may be avoided. (See article in bulletin 111 touching borers.)

VI. DISPOSAL OF AN ORCHARD CROP

Success in apple culture, financially speaking, is just as dependent upon the intelligent and business like disposal of the fruit as upon the cultural methods followed in its production. It is quite possible to grow a good crop of nice fruit and yet through lack of business ability or intelligence, or both, to fail to realize a reasonable profit from its disposal. Success in the business end of fruit growing depends largely upon the following factors:—Picking the fruit at the proper time and in a careful manner; proper grading and packing; the use of attractive packages; proper storage; adequate transportation facilities; placing the fruit on the market in its season and when it is commanding a good price.

Picking.—While there are no hard and fast rules governing the picking of apples, the successful orchardist strives to harvest his fruit when it has reached its full size and has developed, in the case of colored varieties, a normal, or if possible, a maximum amount of color. Apples should not hang until they have begun to ripen if a long keeping fruit is desired. Generally when an apple snaps cleanly from the fruit spur it should be picked.

Pickers should have strong, light ladders, stepladders with broad bases, and a well padded half bushel basket with a strong wooden bale and a heavy "S" shaped wire with which to suspend his basket from the rungs of his ladder or the branches of the tree, thus freeing both hands for picking. It seems needless to say that fruit should be handpicked, yet many apple growers in Vermont do not take the trouble thus to harvest their apples. It is extremely important from the first to the last operation of the harvest that the apples should be so handled as to cause the least possible amount of bruising. As soon as picked, unless the sorting and packing is done in the orchard, they should be placed in

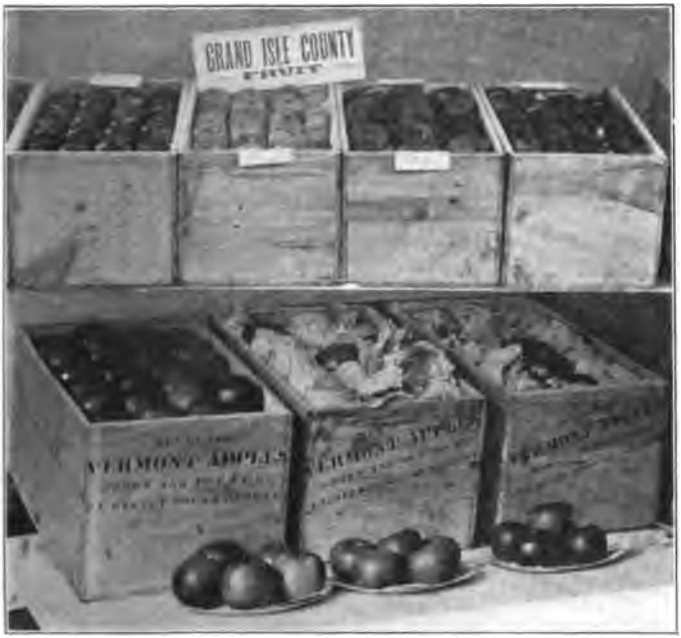

Figure 12. Fancy Vermont apples, carefully picked, properly graded, and attractively packed.

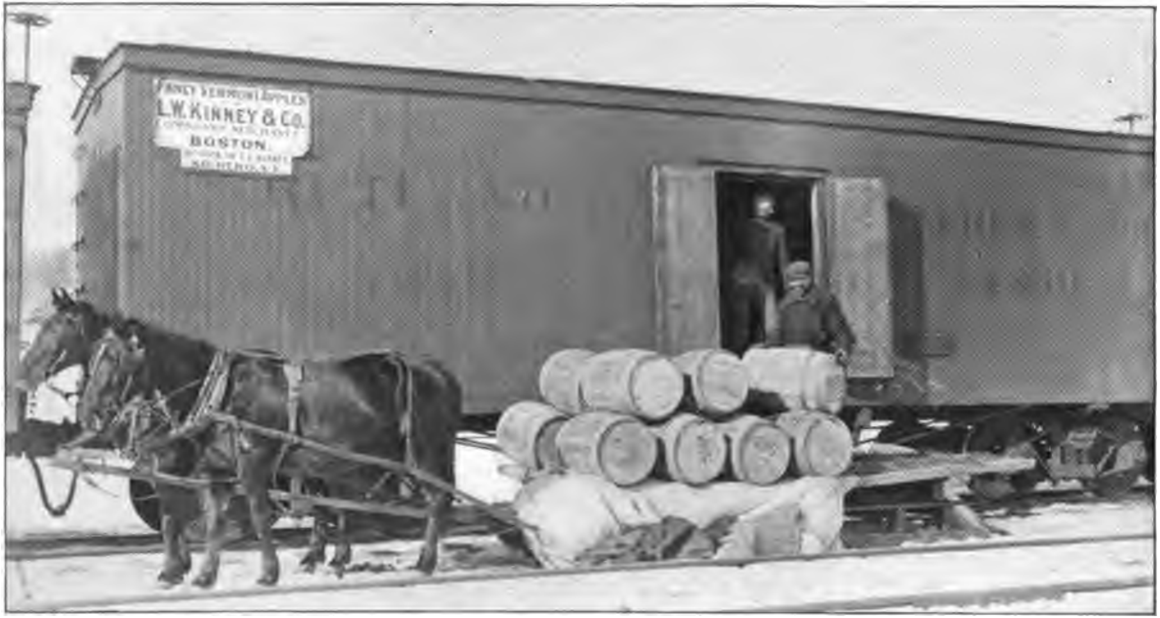

Figure 13. Loading stored apples into a refrigerator car in zero weather. This car runs regularly back and forth between Boston and South Hero for several weeks during the winter, handling cooperative shipments. (See page 99).

barrels or boxes and hauled to the fruit house where they should be cooled off as rapidly as possible.

Grading and packing.—The ability so to grade and to pack apples that, when they are offered for sale, they present an attractive appearance, because of uniformity and minimum amount of injury from transportation, is a valuable asset to the orchardist. This one item determines largely the success or failure of the grower to realize the best market price for his product. In order to present this attractive appearance, the apples must be of a nearly uniform size and color and present few surface defacements. In packing either a barrel or box the package should be carefully faced with fruit which should as nearly as possible represent its average contents. Facers, however, may be somewhat higher colored than the average without seriously misrepresenting the contents of the package. Barrel packages are either single or double faced, usually the latter. In facing a package the stem end is placed downwards. By a judicious selection of facers the packer can usually manage to have a well filled layer. Large interstices or irregular arrangement of the fruit in the facer rows detracts materially from the finished appearance of the package. Likewise, high colored fruit should not be mixed with medium or low colored fruit in the facer row. Uniformity in size, arrangement, color and freedom from blemishes are four points to be kept in mind. (See figure 12).

The observance of these details alone does not, however, insure an attractive package when opened. Another necessary precaution is that the package shall be sufficiently well filled so that when headed it will be just firm enough to hold the fruit in place and not so tight as to bruise a considerable proportion of it. A clean bright barrel should be used in which a plain or corrugated paper cap should be placed to lessen the bruising and add to the attractiveness of the package. The bottom being faced, the barrel should be half filled with fruit poured in carefully by lowering the basket well into the barrel and given a thorough shaking to settle the apples into place. Repeating this operation when the barrel is nearly full, it is then filled a trifle above the chimes, the top layer being arranged as uniformly as possible. The contents of the barrel are then pressed into place with a well padded head specially prepared for this purpose. When this false head is removed, a plain or corrugated paper cap is added, the top cover put on and pressed into place with a screw or lever barrel header and nailed firmly into place. Tough twigs or similar material may be used for cleating and to afford additional security. The writer has received barrels of apples from Vermont fruit growers which had been filled so full that in heading nearly every apple in the package was severely bruised. Others have been received in a slack condition, that is they had not been sufficiently full to allow for shrinkage during shipment and as a result when opened up they presented an even sorrier appearance than those which had been too severely pressed together. Of the two evils the overfull package is to be preferred, yet the packer should strive so to fill his barrel or box that there will be a minimum amount of bruised fruit.

Storage.—The problem of storage, at home or otherwise, is one that sooner or later every large fruit grower must face. A suitable storage room in which to hold one's crop of apples until such time as the market conditions warrant their disposal renders the grower independent of the middleman and usually insures a much better price for his fruit. Community or co-operative storage houses would seem to offer to the smaller growers the best solution of the storage house problem. Without storage facilities the grower has but two choices left to him; to dispose of his product to the commission house buyer; or to enter into an agreement with some reliable commission house, by virtue of which he receives a certain fixed price per barrel for his fruit at the time of shipment in the fall, and a certain percent of the advance, after deducting storage charges, over this fixed price at time of the sale of the fruit to the retailer or consumer. The commission man has the fruit shipped as soon as it is picked and places it in cold storage where it awaits favorable market conditions. By this arrangement, provided the commission firm is a reliable and honest one, and there are many such, the grower often receives a very handsome advance in price over that which he could have obtained for his fruit at the time of harvest.

The storage problem is not so serious in Vermont as in other sections since its climate during the late autumn and winter affords almost ideal conditions for the keeping of fruit. A well insulated building having two or more dead air wall spaces and a good basement answers fairly well. With such a building and some provision for ice, or ice and salt refrigeration during the early fall, apples may be kept just as satisfactorily as in the more expensive city plants equipped with artificial refrigeration.

Transportation.—The importance of adequate transportation facilities can hardly be overestimated. Fortunately most of the fruit growing sections of Vermont are well provided. The difficulty of winter shipments are the greatest drawback. Unless one is a large grower, shipping in carload lots and hence able to secure a refrigerator car which he can re-adapt for his special purposes and is guaranteed fast freight transportation, he runs great risk of his apples freezing in transit. In this as in most lines of business the large orchardist possesses a distinct advantage. The only way to overcome this difficulty is for the small growers of each apple growing center to co-operate in their shipments. Ten growers shipping fifteen barrels each can more easily and quickly load a car and ship it to its destination than can one or two growers. Co-operative shipment of apples during the winter season has been practised for ten or a dozen years in South Hero. No serious loss through delay in transit or in freezing has been experienced. No organization of any kind is needed, neighbors simply clubbing together to fill a car. Each shipper places on each barrel his own shipping number given him by the commission merchant to whom the carload is consigned. The latter makes returns directly to each individual. In this way each orchardist is insured as much secrecy concerning his shipment as though he had sent his goods to market in a separate car. The success of such a scheme of co-operative shipment depends entirely upon the willingness of some one of the shippers to assume the responsibility of securing the car, to see that a sufficient number of barrels are promised to fill it, and to notify each shipper when to deliver his consignment. Much of the success of the South Hero enterprise may be ascribed to Mr. T. L. Kinney, who has been unceasing in his efforts to enlist and to retain the interest of the island orchardists in this project. The plan should commend itself to other communities. (See figure 13.)

Profits.—Replies received to a circular letter of inquiry indicate that the cost of producing a barrel of apples ranges from 25 cents to $1 and over per barrel. The lower amount is undoubtedly much too low while the maximum figure is probably a little high. It is doubtful if a barrel of apples can be grown, picked, and graded for less than from 75 cents to $1 per barrel, cost of barrel included. Such a price of course presupposes the handling of apples on a large scale.

Does commercial apple culture in Vermont pay? If intelligently conducted reasonably satisfactory returns may be expected. Examples have been numerous within the past few years in which the owners of good thrifty apple orchards have realized handsome profits from their investment. In Western New York well managed apple orchards are made to pay ten percent or more on a valuation of a thousand dollars per acre. Under similar conditions of management the same returns ought to be expected in the more favored sections of Vermont. Within the past year or two several sales of apple orchards in Colorado, Washington and Oregon have been reported at from $1500 to $2500 per acre. These prices were not paid by capitalists but by men who expected to realize a profit on their investment. Replies to a circular letter sent to various fruit growers in this state indicate returns of from $20 to $175 per acre. The writer personally knows of larger returns than the higher figure.

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 142

MAY, 1909.

Plant Diseases; Potato Spraying.

I. PLANT DISEASES OF 1908—Pages 104-110.
II. POTATO SPRAYING EXPERIMENTS OF 1908—Pages 111-115.

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BULLETIN 142: PLANT DISEASES; POTATO SPRAYING

L. R. JONES and N. J. GIDDINGS

SUMMARY

I. Plant Diseases of 1908.

The season being exceptionally dry insect injuries and physiological maladies were particularly prevalent. The flea beetle, tipburn, and early blight were especially troublesome; while late blight was absent and scab not as serious as usual. Bordeaux proved efficaceous in all cases, repelling flea beetles and lessening tip burn and early blight injuries. Several minor attacks of leaf blotch and black leg of the potato, of apple, pear and plum scabs, of apple and blackberry rust, fire blights etc., were observed.

II. Potato spraying experiments of 1908.

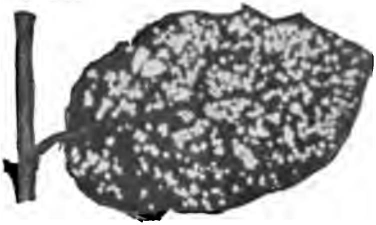
Bordeaux mixtures and lime-sulphur were used to combat fungus injuries. The lime sulphur plots gave a 37 percent larger yield than did the unsprayed plots, while bordeaux twice applied yielded 67 percent more and that applied four times 141 percent more than did the unsprayed plots.

Eighteen years of bordeaux usage at the Station emphasise its value. The lowest gain has been 26 percent, the highest 215 percent, the average 92 percent.

I. PLANT DISEASES OF 1908

The season of 1908 was an extremely dry one. Rarely has so droughty a summer been known in New England. Forest fires, dried up springs and wells, parched pastures, short hay crops and discouraged farmers were common. One good outcome, however, came to pass; for as a result most of the diseases due to vegetable parasites were held in check. Certain other maladies which are primarily due to insects or to physiological disturbances of the affected plant were at the same time aggravated.

POTATO DISEASES



Flea beetle injuries.

Insect injuries. Dry weather tends to aggravate insect injuries. It favors the development and activity of the pests and so checks the growth of the plants that they do not recover promptly from the injuries thus inflicted. The usual activities of the colorado beetle began to be evident in June. As explained on page 114, the lime-sulphur spray proved ineffective against this beetle and arsenites had to be used in addition to protect the plants on the plots where this remedy was being tried. The flea beetles were unusually abundant from mid-summer onwards, and caused much damage on all the potato plots except those sprayed with bordeaux mixture.

Tip-burn. This malady, being due to dry heat in conjunction with any other unfavorable conditions, was especially in evidence in 1908. Many potato growers who complained that their crops were attacked by early blight were really suffering from this trouble. Such a season offered an exceptionally good opportunity for determining the efficiency of bordeaux and other spray mixtures in preventing tip-burn. Experiments with this particular point in view were undertaken with results as reported on page 113. These trials give conclusive evidence as to the value of bordeaux mixture in reducing tip-burn.

The appearance of the leaves when affected by this malady is well indicated by the cut on page 110. It is so common for potato growers in dry seasons to confuse this malady with blight that it were worth while to learn to discriminate. Yet since bordeaux is a specific in any event, the importance of a careful diagnosis is not economically important.

Early blight. The early blight fungus, *Alternaria solani,* caused a considerable amount of damage in some potato fields in 1908. In general, however, the loss was not great except on the weaker plants where the attacks of this fungus were followed by tip-burn. In combination these incursions serve to reduce the vigor and to shorten the life of unprotected plants. Spraying with bordeaux mixture checks the fungus[1] and also lessens the tip-burn.

The appearance of leaves affected by this malady in its earlier stages is pictured on page 111.

Late blight. This disease, due to the fungus *Phytophthora infestans,* was not found in the potato fields about Burlington in 1908, nor was it reported to the Station from any other place in Vermont. It was not very general in its occurrence in this state in 1907 and evidently its non-appearance in 1908 is to be attributed to this fact, coupled with the unusually dry weather. This was a general experience throughout North America. In connection with the special studies of this fungus at this Station requests were made in the autumn of 1908 for specimens of potato tubers showing the dry rot caused by this fungus. None was obtainable from the following Experiment stations: California, Colorado, Connecticut (New Haven), North Dakota, Florida, Delaware, Illinois, Indiana, Kentucky, Iowa, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New York (Geneva and Ithaca), Nevada, Pennsylvania, Rhode Island, Texas, Wisconsin, Wyoming, Porto Rico, Ottawa, (Canada). Specimens were received through the courtesy of the Experiment stations from Storrs, Conn., and Wooster, Ohio, and through the officers of the Bureau of Plant Industry from

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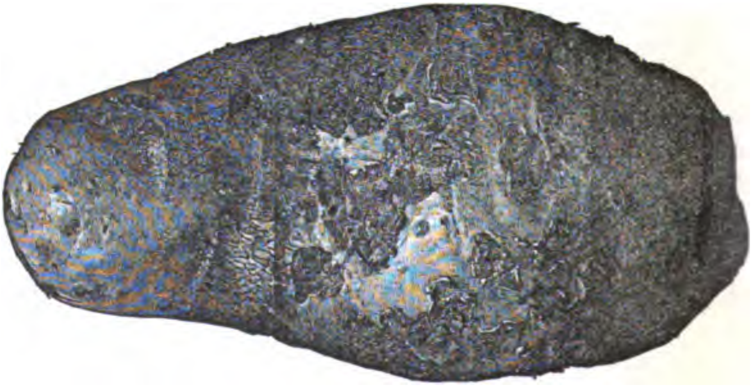
[1] See Vt. Sta. Rpt. 18, p. 275 (1905).

Louisburg, Pa. In addition specimens were secured from Germany, Holland, Ireland and Scotland, which is of interest incidentally as showing how much more prevalent the malady was in European countries than in America. In view of the general suppression of the late blight in America in 1908 it does not seem probable that there will be any epidemic of it during the coming summer, 1909. However the conditions determining the recurrence of this malady are not sufficiently well understood to justify any confident prophecy, and growers should not relax vigilance on this account.

Potato leaf blotch. This is a fungus trouble (*Cercospora concors*) of minor importance resembling early blight in certain respects. It was again found in one of the same gardens where it has been observed the two preceding seasons. It seems clear, therefore, that it persists where once established. There was, however, less of it than two years ago and there seems no reason for serious practical concern about it.



A scabby potato tuber.

Potato scab. The tuber disease attributed to the fungus *Oospora scabies* was not so troublesome as usual last year. Part of the experimental plots were located on badly infected soil where in the moister season of 1907 the tubers were practically worthless because of scab. They were badly attacked again in 1908 but less severely than in 1907. Regardless of the season avoidance of infected soil is essential for a clean crop. While seed disinfection is effective only where clean soil is planted, it is, nevertheless, a safe precaution in all doubtful cases. Our practice is, therefore, to soak the seed tubers two hours in a disinfecting solution of 1 pound of formalin in 30 gallons of water. This is best done some days in advance of planting, spreading the tubers after disinfection in a thin layer on the grass or barn floor to favor prompt drying.

Black-leg of the potato. This malady is characterized by a rotting of the base of the potato stem, principally below ground. It leads to a spindling top with up-curling leaves and terminates as a rule in the death of the affected stems before the tubers are set. It is attributed to bacteria. But little of it was seen in the experimental plots, less than in each of the two moister seasons of 1906 and 1907. The writers have come to expect it chiefly on cool moist soils which are inadequately underdrained. Specimens have been received this year from correspondents in Vermont, Massachusetts, and New York, and have been received also from Canada, showing a general distribution of the malady in the northeastern potato section. Conclusions to date are that the germs are carried on the seed tubers, but that they are not sufficiently virulent to cause serious loss unless soil conditions are especially favorable. This would indicate seed disinfection as the proper remedy in case the trouble is anticipated, using the formalin method outlined above.

ORCHARD DISEASES

No especial work was underway upon orchard or garden crops, and the following brief notes are based upon general observations supplemented by specimens submitted by correspondents.

Apple scab. (*Venturia inaequalis*) was less prevalent and destructive than usual.

The same statement holds for the closely allied *Pear scab* (*Venturia pirina.*)

Apple rust caused by the fungus *Gymnosporangeum macropus* was reported as serious by two correspondents. This causes rusty brown spotting of the apple leaves, which when badly attacked begin to fall in midsummer, thus seriously weakening the tree. The infection comes from the galls on red juniper (cedar apples). The infection may be reduced by spraying the apple foliage in early spring, but this is at best only partially successful, whereas the destruction of the junipers ends the trouble.[1] Since these have slight value for ornament or other purpose it is the part of wisdom to remove them from the neighborhood of apple orchards.

Fire blight. This is the bacterial disease (*Bacillus amylovorus*) which is most destructive on pear, less so on apple, and occasional on plum. Only one orchardist complained of it last year, nor has it been serious for several years. Orchardists may well take advantage of such a period when natural agencies are combining to hold the malady in abeyance. Small effort in the way of pruning will suffice now to eradicate it wholly from any orchard.

Plum scab, due to the fungus *Cladosporium carpophilum* was reported by one correspondent. Early spraying is called for to prevent this malady, beginning promptly after the fruit is set.

GARDEN DISEASES

Only three of these merit special mention.

Blackberry rust. The orange rust of the leaves (*Gymnoconia interstitialis*) was reported by several berry growers. It is common in wild plants and needs to be guarded against in cultivated plantations. Since when once introduced it is perennial in the plant, diseased stools should be promptly uprooted and burned. If detected before the ripening of its spores, no general spraying is called for.

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[1] See Vt. Sta. Rpt. 6. p. 83 (1892).

Pea blight. Specimens of blighting young plants both of garden peas and of sweet peas were received from several correspondents. This is a stem disease similar to if not identical with that reported from Ohio and there attributed to the fungus *Asilcochyta pisi.*[1] No wholly satisfactory remedy has been worked out for this malady but it is at least wise not to replant for several years in soil where the crop has suffered.

Bean anthracnose. This is often called bean rust. It is due to the fungus *Calletotrichum lindemuthianum* which attacks chiefly the pods, causing ulcer-like spots. It becomes a serious matter as soon as bean culture assumes large proportions. Since it is carried in the seed the securing of sound seed from a healthy field is of first importance, although not always practicable. Spraying with bordeaux mixture has proved efficacious.

Witches broom of birch. Specimens of branches of diseased European white birch were received from a nurseryman the latter part of the summer of 1908. These terminated with the bushy, distorted growth known as "witches brooms." Their general appearance led to the suspicion that the trouble is due to the European fungus *Exoascus turgidus,* which has not heretofore been observed in America. Examination revealed no fruiting fungus to enable us to verify this suspicion. The nurseryman was advised to destroy the diseased trees and to watch the balance of his stock for any reappearance of the malady.

II. POTATO SPRAYING EXPERIMENTS OF 1908

These trials were planned in continuation of the policy to make annual trials of the gain from spraying potatoes with bordeaux mixture; to learn the relative gains, season by season, of sprayings varying in number and date; and to test the merits of any promising new fungicides in comparison with bordeaux mixture.

With these questions in mind sprayings have been made on two fields of potatoes; one a light sandy loam planted May 15 with the Green Mountain variety; the other a heavy clay loam where two varieties White Star and Irish Cobbler were included, these having been planted May 21. The soil conditions were fairly uniform in each field and the sprayed plots consisted of three rows each 300 feet long.

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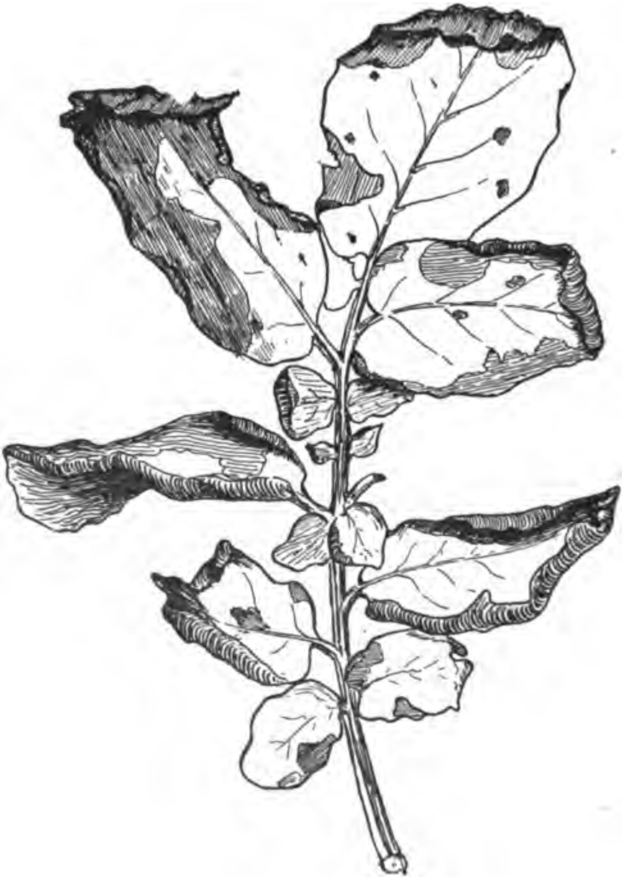
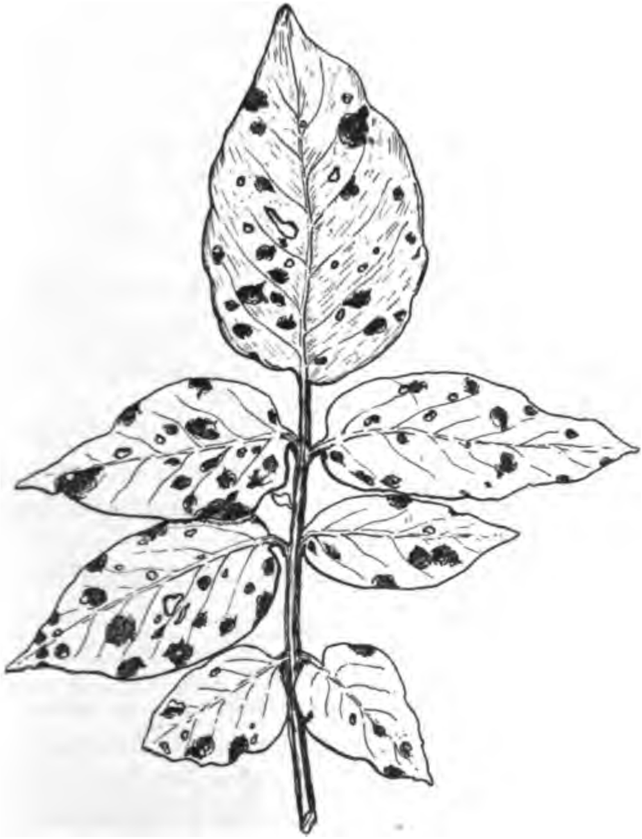
[1] Ohio Sta. Bul. 173. (1906).



Tip burn of potato leaf.

As already explained, there was no late blight or rot in the field and but little early blight. But little of the gain from the spraying is, therefore, due to the fungicidal action of the mixtures in any case. The benefits are rather due to the deterrent action upon insects and the reduction of tip-burn. This latter gain appears to be associated with the indirect action of the spray mixture, which is probably due in part to its physical relation to the leaf as a light screen, and in part to the chemical action of the copper on the leaf tissue.



Early blight of potato leaf.

The *bordeaux mixture* used consisted of one pound copper sulphate, one pound lime, ten gallons of water, applied at the rate of one hundred and fifty galons per acre in June and July applications and two hundred gallons per acre in August.

The *self-boiled lime-sulphur mixture* consisted of 15 pounds of lime, to which while it was being slacked and boiling hot was added 10 pounds of flours of sulphur. This was then slowly diluted with water to make fifty gallons and was applied at the same rate as the bordeaux mixture.

The *control* rows were kept free from the colorado beetle by dusting them with paris green-lime, consisting of one pound paris green in twenty pounds of air slaked lime, applied at the rate of thirty pounds per acre.

The plots with dates of treatment were as follows:

FIELD A, SANDY LOAM, VARIETY, GREEN MOUNTAIN

Plot 1. Bordeaux-paris green mixture; four times, June 26, July 9, August 5, 26.

Plot. 2. Lime-sulphur mixture; four times, June 26, July 9, August 5, 26. (Supplemented by paris green-lime).

Plot 3. Control; paris green-lime as needed to control the colorado beetle.

Plot 4. Bordeaux-paris green mixture; two times, August 6, 26.

FIELD B, CLAY LOAM

Plot 5. Irish Cobbler. Bordeaux-paris green mixture; four times, July 2, 20, August 6, 25.

Plot 6. Irish Cobbler, (control); paris green-lime as needed to control the colorado beetles.

Plot 7. Irish Cobbler. Lime-sulphur four times; July 2, 20, August 6, 25. (Supplemented by paris green-lime).

Plot 8. White Star. Lime-sulphur four times; July 2, 20, August 6, 25. (Supplemented by paris green lime).

Plot 9. White Star (control) paris green-lime as needed to control the colorado beetles.

Plot 10. White Star. Bordeaux mixture two times; August 8, 26.

The colorado beetles paid so little attention to the presence of the lime-sulphur mixture that it was found necessary to dust plots 2, 7, and 8 with paris green-lime in order to save them from these insects.

The beneficial effects of the bordeaux mixture as compared with the other treatments became apparent after the second application and increased relatively till the close of the season. One result of the spraying was the lessened amount of tip-burn on these sprayed plots. To secure more exact data as to this matter counts were made on three average hills of each plot of Field A., on August 19 with the following result. The figures indicate the average number of leaflets on each hill that were not affected by tip-burn.

Plot	1	Bordeaux, four times	515
"	2	Unsprayed	95
"	3	Bordeaux, two times	247
"	4	Lime-sulphur	236

From this showing it is evident that the benefits are most marked from four sprayings with bordeaux mixture which gave an average of over five times as many healthy leaflets per hill as the control plants showed.

Since tuber production is directly dependent upon healthy foliage the condition of the leaves is in general a fair index to yield. The above figures were, therefore, in a way prophetic of the yields secured when the crop was harvested in October.

Field A. Sandy loam. Plots 1-4 Green Mountain. Yields in pounds per plot of three rows each 300 feet long.

Plot.	Total.	Large tubers.	Small tubers.	Gain % large tubers.
1. Bordeaux mixture, four times	581	542	39	154
2. Lime-sulphur	324	275	49	29
3. Control (paris green)	253	213	40	..
4. Bordeaux mixture, two times	436	394	42	85

Field B. Clay loam. Plots 5-7 Irish Cobbler; 8-10 White Star. Yields in pounds per plot of three rows each 300 feet long.

Plot.	Total.	Large tubers.	Small tubers.	Gain % large tubers.
5. Bordeaux mixture, four times	283	239	44	128
6. Control (paris green)	138	105	33	..
7. Lime-sulphur, four times	216	172	44	64
8. Lime-sulphur, four times	237	179	58	17
9. Control (paris green)	199	153	46	..
10. Bordeaux mixture, two times	269	227	42	48

As will be seen from these figures there was some gain from the lime-sulphur mixture, averaging 37 percent over the corresponding control plots. As compared with this, however, two sprayings with bordeaux mixture gave a gain of 67 percent or nearly twice as much as the four applications of lime-sulphur, while from four sprayings with bordeaux mixture the gain was 141 percent or nearly four times that from similar sprayings with lime-sulphur. Under the conditions of dry heat that prevailed last summer four sprayings gave distinctly better results than two sprayings.

The following table summarizes the gains from the use of bordeaux mixture on late potatoes for the last 18 years at the Vermont station.

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per acre		Gain per acre
		Sprayed	Not sprayed	
White Star,				
May —, 1891	Aug. 26, Sept. 8,	313 bu.	248 bu.	65 bu. or 26%
May 20, 1892	July 30, Aug. 13, 25,	291 "	99 "	192 " " 194 "
May 20, 1893	Aug. 1, 16, 29,	338 "	114 "	224 " " 196 "
Apr. 26, 1894	June 16, July 17, Aug. 30,	323 "	251 "	72 " " 29 "
May 20, 1895	July 25, Aug. 13, 31,	389 "	219 "	170 " " 78 "
Polaris,				
May 15, 1896	Aug. 7, 21,	325 "	267 "	68 " " 26 "
June 1, 1897	July 27, Aug. 17, 28,	151 "	80 "	71 " " 89 "
White Star,				
May 10, 1898	July 21, Aug. 10,	238 "	112 "	126 " " 112 "
Average, 3 varieties,				
May 18, 1899	July 26, Aug. 17, Sept. 8,	229 "	161 "	68 " " 42 "
Delaware,				
May 23, 1900	Aug. 4, 23,	285 "	225 "	60 " " 27 "
May 25, 1901	July 20, Aug. 21,	170 "	54 "	116 " " 215 "
May 15, 1902	Aug. 1, 20,	298 "	164 "	134 " " 82 "
Green Mountain,				
May 1, 1903	Aug. 10,	361 "	237 "	124 " " 52 "
Delaware				
May 25, 1904	Aug. 1, Sept. 1,	327 "	193 "	134 " " 69 "
May 15, 1905	Aug. 2, 21,			
Green Mountain,		382 "	221 "	161 " " 73 "
May 27, 1906	Aug. 13, 22,	133 "	101 "	32 " " 82 "
May 1, 1907	July 16, 25, Aug. 8, 22,	171 "	63 "	108 " " 175 "
May 15, 1908	June 26, July 9, Aug. 6, 26,	156 "	65 "	91 " " 140 "
	Average of 18 years,	271 "	159 "	112 " " 92 "

It is hardly necessary to comment further on these figures than to emphasize the following points:

The mixture consists of five pounds copper sulphate, five pounds lime, fifty gallons (one barrel) water, to which is added if needed a half pound paris green in order to combat the colorado beetle.

Spraying should begin while the plants are still healthy and vigorous.

Spraying should be thoroughly done, at least two barrels of the mixture per acre being applied.

If in doubt as to when to begin, start earlier and spray oftener than seems necessary, since an excess of the mixture does no harm.

Bulletin 113 (free for the asking) discusses spraying and gives directions for the preparation and use of many kinds of fungicides and insecticides.

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'28/-,

UNIV. OF MICH.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN NO. 143
JUNE, 1909

Commercial Fertilizers
The Service of a Fertilizer Control
Soil Physiography

I. Table of Contents and Summary—Pages 119-122
II. Introduction—Pages 123-130
III. Results of Fertilizer Inspection—Pages 131-143
IV. Relation Between Selling Price and Valuation—Pages 143-152
V. Analyses of Licensed Fertilizers—Pages 152-167
VI. Analyses for Five Years—Pages 168-177
VII. The Service of a Fertilizer Control—Pages 178-195
VIII. Soil Physiography—Pages 196-255
IX. Index—Pages 256-260

BURLINGTON:
Free Press Printing Company,
1909.

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☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 143: COMMERCIAL FERTILIZERS; THE SERVICE OF A FERTILIZER CONTROL; SOIL PHYSIOGRAPHY

By J. L. Hills, C. H. Jones and H. L. Miner

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SUMMARY

III. Results of inspection. The Station has drawn from dealer's stocks and analyzed 133 of the 136 licensed brands, the output of 12 companies, all this year's goods.

1. Quantity of plant food. Eighty-three percent of the brands met their guaranties. Four brands failed to afford a commercial equivalent of their promises, only two of these being seriously deficient as indicated on pages 131-132.

2. Quality of plant food. The quality of the crude stock used in manufacturing the goods as a rule seemed all that could be wished. A few criticisms, however, may be made. Two-fifths of the brands, mostly the lower grades and lower priced goods, carried no water-soluble nitrogen. An inferential claim, that sulphate of potash was used, is made for three-fifths of the brands; only two brands contain any appreciable quantities of sulphate. The organic nitrogen used seems to have been of good quality in most cases, but more brands than usual seem doubtful in this respect. Pages 139-143.

IV. Selling prices and valuations. The average selling price was $31.43; the average valuation, $18.84. Two dollars

in five spent for mixed fertilizers was paid to the manufacturer, railroad, and selling agent for their work, while only three of the five paid for plant food. But 53 cents' worth of plant food was bought for a dollar in average low grade goods, and 58 cents worth in medium grade goods. The average high grade brand, however, afforded 65 cents' worth for a dollar. Some Vermont dealers paid fully twice as much for plant food as did others. Pages 142-152.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 152-167.

VI. A comparison of analyses of brands for five years shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods. Pages 168-177.

VII. The service of a fertilizer control, the methods of its financing, of sampling and analysis, of the publication of results, together with a detailed exposition of the interpertation of an analysis, as well as an explanation of the use which buyers may make of the analytical and the other statements of the control; all these are outlined on pages 178-195. The interpretation of the analyses in particular is made in great detail and in the simplest manner possible in the hope that it may serve to make these data more intelligible. Pages 195.

VIII. A discussion of soil physiography is offered on pages 196-254. This attempts to cover the sundry internal and external forces, particularly those of the air, ground water, water in motion, ice action and life, in their relations to rock disintegration and soil formation. This article is especially summarized on pages 242-244.

IX. The technical terms which are used in the article on soil physiography are defined in the glossary, pages 246-254 and the entire bulletin is thoroughly indexed on pages 255-260.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletins of the Station dealing with commercial fertilizers shall not only give the results of the analyses of these goods, but shall also publish "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." Two bulletins are issued each spring, in April and in June. The first gives the analyses of about 60 brands, the valuation schedule, a discussion of its use, a table of analyses for five years, etc. The second discloses the analyses of all the brands collected, shows their composition during the past five years, contains a general review of the trade of the State, makes statements as to the quantity and quality of the plant food sold in the sundry brands, considers the comparative values of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.

These general matters are annually reviewed. In addition thereto, in the second and larger bulletin there is yearly presented a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99 and 130 and as well as in this issue. These glossaries will be added to from time to time in the future. Anyone failing to grasp the meaning of terms other than those defined in the glossary in this issue used should get 99 or 130 and make use of their glossaries. They are free for the asking. The larger bulletin is always thoroughly indexed.

The following statement outlines the "features" of the preceding bulletins. The table of contents on pages 119-121 serves to introduce the reader to the matter contained in this issue:

Bulletin 93 (1902). *Formulas for home mixing.*—(56 pages).

Bulletin 99 (1903). *Vermont's usage of fertilizers. Concerning fertilizer buying. Deficient plant food.*—(88 pages).

Bulletin 108 (1904). *Classification of commercial fertilizers sold in Vermont. Farm manures.*—(68 pages).

Bulletin 116 (1905). *How, when and what to use.*—(104 pages). (Available only as a loan).

Bulletin 123 (1906). *Concerning the purchase of plant food. The moisture relations of the soil* (68 pages).

Bulletin 130 (1907). *Soil biology in its relation to fertilization.* (144 pages).

Bulletin 135 (1908). *Soil deterioration and soil humus.* (128 pages).

These articles were written in 1902, 1903, 1904, 1905, 1906, 1907 and 1908; but they are just as applicable to the purchase and use of fertilizers in 1909 and succeeding years as they were when first penned. The reader of this bulletin who does not own a 93, a 99, a 108, a 123, a 130 or a 135, and wants either or all of them, has but to ask to receive. No. 116, being nearly exhausted, is only issued on loan to those who will promise to return it after it has served their purposes. Circular No. 1—free for the asking—outlines all these bulletins.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate ingredients used to manufacture the same, or

* * * bone meal, land plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.)

It provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in distilled water, and of soluble, reverted, insoluble, available and total phosphoric acids, and the maximum percentage of chlorin." (Sec. 4976 P. S.)

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) " * * * shall annually * * * pay * * * a license fee of one hundred dollars," which will permit "the sale of not more than five brands of commercial fertilizer, which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than this number of brands, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of five." "The license fee(s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S.)

It provides that any person offering unguarantied, overguarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the state treasurer, for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs. 4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.)

The full text will be furnished on application.

LIST OF LICENSEES

The following companies have paid licenses as required by law on the brands shown in the tables on pages 156-167, and on the three brands mentioned on the next page as uncollected. The sale within the State of these brands, and of these brands only, is legal. All local agents as well as intending purchasers are warned against the handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the one hundred dollars license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 2 Rector St., New York, N. Y.
Armour Fertilizer Works, 861 Calvert Building, Baltimore, Md.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
Buffalo Fertilizer Co., William St., near city line, Buffalo, N. Y.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 24-26 Stone St., New York, N. Y.
Essex Fertilizer Co., 39 No. Market St., Boston, Mass.
Lister's Agricultural Chemical Works, Newark, N. J.
Lowell Fertilizer Co., 44 No. Market St., Boston, Mass.
New England Fertilizer Co., 42 No. Market St., Boston, Mass.
Parmenter & Polsey Fertilizer Co., 40 No. Market St., Boston, Mass.
Rogers & Hubbard Co., Middletown, Conn.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 70 towns and villages in Vermont during the spring of 1909 and drew 273 samples from dealers' stocks, representing 133 distinct brands, the output of 12 companies licensed to sell in Vermont. These companies licensed 136 brands.[1] No shipments of the following brands were found:

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[1] Since the issuance of Bulletin 140 the Parmenter and Polsey Fertilizer Co. has licensed the sales of the Aroostook Special, Maine State, and Special Potato goods, and the American Agricultural Chemical Co., the sale of the North Western Challenge Crop Grower.

Buffalo Fertilizer Co.'s High Grade Fertilizer.
Armour Fertilizer Co.'s General Farm.
New England Fertilizer Co.'s High grade with Ten percent Potash.

SCHEDULE OF TRADE VALUES

The following schedule of trade values to be used in this State in 1909 is the one agreed upon by the Experiment stations of New England and New Jersey, after a careful study of prices ruling in the larger markets. The 1908 schedule is also shown for purposes of comparison.

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS FOR 1908 AND 1909

	1908 cts. per lb.	1909 cts. per lb.
Nitrogen in nitrates	18½	16½
Nitrogen in ammonia salts	17½	17
Organic nitrogen in dry and fine ground fish, blood and meat and in mixed fertilizers	20½	19
" " in fine ground bone and tankage	20½	19
" " in coarse bone and tankage	15	14
Phosphoric acid soluble in water	5	4
" " soluble in ammonium citrate[1]	4½	3½
" " in fine ground bone and tankage	4	3½
" " in coarse bone and tankage	3	3
" " insoluble (in water and in ammonium citrate[1]) in mixed fertilizers	2	2
Potash as high grade sulphate and in mixtures free from muriate (chlorid)	5	5
Potash as muriate	4¼	4¼

These trade values are, as nearly as can be estimated, the average figures at which, in the six months preceding March 1st, the respective ingredients could be bought at retail for cash in the larger markets (Boston, New York, etc.), in the *raw materials,* unmixed. They also correspond to the average wholesale prices for six months ending March 1st, plus about 20 percent in the case of goods for which there are wholesale quotations. The valuations obtained by the use of the above figures will be found to agree fairly with the reasonable average retail price in the large markets of standard raw materials.

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[1] Dissolved from 2 grams of the prepared sample, previously extracted with pure water, by 100 c. c. of a neutral solution of ammonium citrate, sp. gr. 1.09, in 30 minutes at 65 degrees C, with agitation once in five minutes.

In applying trade values to mixed goods, organic nitrogen is valued at 19 cents a pound; nitrogen as nitrate of soda and as sulphate of ammonia at 16½ and 17 cents a pound respectively; soluble, reverted and insoluble phosphoric acids at 4, 3½, and 2 cents a pound respectively; and potash at 4¼ cents a pound, if there is sufficient chlorin to unite with all the potash; if not, it is valued at 5 cents.

A valuation is determined as follows: The percentages or pounds per hundred of each ingredient (i. e., nitrate nitrogen, ammoniacal nitrogen, organic nitrogen, soluble phosphoric acid, reverted phosphoric acid, insoluble phosphoric acid and potash), are multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

THE MEANING OF COMMERCIAL VALUATIONS

That there may be no misconception and that the reader may clearly appreciate what these valuations are and what they are not, it is our custom to call attention repeatedly to the fact that *a station valuation does not represent the proper selling price of a fertilizer at the point of consumption.* Neither should it be inferred that the ingredients in the brand in question have of necessity the commercial value indicated. It may be greater or less than is shown. The Station does not pretend dogmatically to state what may be the commercial worth or valuation of any one of the many brands of fertilizer sold in the Vermont market, as it cannot always affirm the quality of the crude stock used, particularly the nitrogenous material. The valuation system is based on the assumption that all brands are composed solely of high grade ingredients, an assumption which is probably erroneous. "Valuations" should not be construed as showing the commercial worth of a given fertilizer, but the *retail trade value or cash-cost of amounts of nitrogen, phosphoric acid and potash, equal to those contained in a ton of the brand in question, in unmixed, standard raw materials of good quality, at the seaboard.* They bear no necessary relationship to the agricultural or the crop producing value of the goods but simply indicate the current market prices of standard commercial articles, more particularly nitrate of soda, sulphate of ammonia, dried blood, tankage, ground bone, acid phosphate, muriate of potash, sulphate of potash and kainit.

Valuations thus construed, while not infallible, are helpful.

(*a*) To show whether a given fertilizer is worth its cost from the *commercial* standpoint.

(*b*) As a common basis on which to compare the *commercial* values of different brands, enabling buyers to note whether prices asked are warranted by values contained.

Valuations, then, simply show the cost of ready-made plant food. Its cost, however, is but one of the many charges which determine the retail cost of commercial fertilizers, just as the leather from which a pair of shoes is made is but one of the many charges which go to make up the retail cost thereof. The plant food must be also mixed, stored, reground, bagged, loaded, and freighted. Then too, commissions to agents and dealers, the expense of selling on long credit, the item of bad debts, the interest on investments, the depreciation of the manufacturing plant, profits, etc., are also proper and fixed charges; yet not one of them contributes to plant growth. Commercial fertilizers are usually applied in the mixed form, but this is simply a matter of convenience, for as good results may be obtained by the separate application of the crude ingredients.

An illustration may serve to make these statements more clear. A farmer buys in Boston or New York 50 pounds of nitrate of soda, 350 pounds of dried blood, 1,475 pounds of acid phosphate, and 125 pounds of muriate of potash, and he mixes these ingredients together at home on his barn floor, as thousands have done before him. The cost of this ton after mixing will be made up as follows: (*a*) Cost of material in the market; (*b*), cost of transportation; (*c*) cost of mixing. The first item (*a*) entering into the total cost is the only one included in the "valuation." If to (*a*) be added (*b*), (*c*), and, also, the expenses of selling through agents, long credits, bad debts, etc., we have the factors involved in the cost of fertilizers delivered in Vermont. Clearly the local selling price must of necessity exceed the "valuation." Since the cost of mixing and selling varies with different companies, and since freight rates to the different sections of the State are unlike, no arbitrary sum to cover these charges can be assigned. These can be estimated best by the consummer to fit his local conditions. He should expect to pay and does pay not only for the plant food contents of his purchase, but also a fair margin to cover the expenses incident to assemblage, manufacture and sale, as well as for the convenience and other advantages pertaining to the use of ready-made and locally supplied plant food. If the selling price does not exceed the valuation by more than 35 or 40 percent it may not be too high, but in proportion as the excess increases beyond this point there is reason to question the economy of the purchase. The reader is referred for a further and somewhat full discussion of this matter to pages 81-86 of bulletin 99 (sent without charge on request); also to the special article in this issue dealing with the exposition of the meaning of the analyses and valuations, pages 183-192.

III. RESULTS OF FERTILIZER INSPECTION

1. AS TO QUANTITY OF PLANT FOOD

(*a*). COMPARISON OF GUARANTIES AND ANALYSES

The general quality of the brands sold this year as judged by analysis is better than has obtained during the past two years; and if the peculiar occurrance discussed on this page and the next were eliminated the outcome would be better than for several years. Twenty-two brands of the entire number are deficient, but not a single one is deficient in more than one ingredient. These plant food shortages are distributed as follows: nitrogen 6, available phosphoric acid 7, potash 9. Ten of these twenty-two deficiencies, moreover, are just barely over the dead line[1] of 0.10 percent shortage of nitrogen and 0.20 percent of phosphoric acid or potash; hence there are only twelve shortages in 390 guaranties or one in thirty-three which are really worth noticing.

Four brands fail to afford the commercial equivalent of their guaranties. Only two brands are seriously involved—as indicated below—while the other two are only shy 4 and 3 percents respectively of their commercial equivalents. Phrasing this matter another way, these deficiencies in neither case are large enough to cavil over, since the differences in ton values would barely purchase a frugal meal. In short inadequate mixing which affords considerable excesses of one or more ingredients balancing greater or less deficiencies of others are at fault in practically all the brands; and in no case is there reason to suspect intent to defraud.

The sampling agent found a consignment of Armour fertilizers at Bellows Falls, analyses of which showed marked deficiencies in some of the ingredients guarantied. Check samples were drawn at Bellows Falls and also from another consignment at West Brattleboro. This procedure is the regular one at this station in such cases, as is indicated in the statement three paragraphs further on. All these samples, twelve in number, were analyzed. Some of these analyses showed an overrun in certain ingredients which offset the underrun in other ingredients and gave the consumer the commercial equivalent in plant food. The Complete Manure and Corn Special goods, however, do not afford the commercial equivalent of their guaranties. A sample of Corn Special drawn at West Brattleboro also failed to afford the commercial equivalent of the guaranty. The attention of the manufacturer has been called to these results and assurance secured that full remuneration will be made to the consumers.

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[1] A brand which analyses within 0.10 percent nitrogen or 0.20 percent available phosphoric acid or potash of guaranty is deemed to be up to guaranty.

This is the first year that goods have been sold by the Armour Fertilizer Works in Vermont, although they have been doing business in other New England states for the past twelve or fifteen years. The inspection reports of recent years issued in Maine, Massachusetts, Connecticut, New York, and other states indicate that the goods as shipped by the Armour Fertilizer Works to the consumers in those states, with such occasional exceptions as may and do occur with the brands of the best of companies, have met the guaranty statements made for them by the manufacturer. The writer does not deem that the analyses of the Bellows Falls samples show manipulation with intent to defraud in any way. The manufacturer is investigating the cause of the discrepancies and, as above stated, will make full reparation to the actual consumers.

It is perhaps needless to remark that *the statements made above are not implications of the agricultural values of the goods which may fail to meet guaranties.* These statements simply call attention to a fact, viz.: that certain brands do not carry as much of certain forms of plant food as their several manufacturers state they contain; only this and nothing more.

Whenever guaranties were not made good the analytical work was repeated, and, frequently, recourse was had to other samples, taken a second time from the original shipments. In several cases when results seemed open to question, other samples were elsewhere drawn. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were also instituted with a view of minimizing error and standardizing results. This general procedure has been in vogue at this Station for years, and is thought to minimize to the last degree the likelihood of error in sampling or analysis.

The condensed results of 15 years' inspection of the Vermont fertilizer trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1895	92	76	16	83	95
1896	110	91	19	83	99
1897	134	113	21	84	94
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	93	38	71	94
1906	130	110	20	85	98
1907	129	98	30	77	94
1908	130	92	38	71	95
1909	133	111	22	83	96

The table on page 134 shows the number of brands sold by the different companies licensed in the State, the number of guaranties (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good within 0.10 percent of nitrogen or 0.20 percent of available phosphoric acid or potash.

Ten of the twelve companies contribute brands to the delinquent list. Four furnish a single brand each; one affords two; four others three apiece and one, four, being in two cases more than half the total number sold.

MAINTENANCE OF GUARANTIES BY LICENSEES

NAME OF COMPANY	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands not making good the commercial equivalent of the guaranty
American Agricultural Chemical Co........	4	11	0	0
do. H. J. Baker & Bro. Branch......	3	9	0	0
do. Bradley Fertilizer Co. Branch....	10	29	1	0
do. Clark's Cove Fert. Co. Branch....	3	9	0	0
do. Cleveland Dryer Co. Branch.....	3	9	0	0
do. Crocker Fert. & Chem. Co. Branch	4	12	0	0
do. Cumberland Bone Phos.Co. Branch	3	9	0	0
do. L. B. Darling Co. Branch........	2	6	0	0
do. Great Eastern Fert. Co. Branch..	4	12	1	0
do. Pacific Guano Co. Branch........	3	9	0	0
do. Quinnipiac Co. Branch..........	4	12	0	0
do. Read Fertilizer Co. Branch.......	6	17	0	0
do. Henry F. Tucker Co. Branch.....	3	9	0	0
do. Williams & Clark Fert. Co. Branch	6	18	1	0
American Agricultural Chemical Co.—Total	58	171	3	0
Armour Fertilizer Works	4	11	3	2
Bowker Fertilizer Co.	14	41	3	0
Buffalo Fertilizer Co.	6	16	2	1
Burlington Rendering Co.	2	6	1	0
Coe-Mortimer Co.	6	17	4	0
Essex Fertilizer Co.	6	18	1	0
Lister's Agricultural Chemical Works......	9	26	1	0
Lowell Fertilizer Co.	8	24	1	0
New England Fertilizer Co................	4	12	0	0
Parmenter & Polsey Fertilizer Co..........	8	24	0	0
Rogers & Hubbard Co....................	8	24	3	1
Total.........................	133	390	22	4

The range of composition and the closeness with which guaranties are met are shown in the first table on the opposite page. The condition of affairs it discloses, a close hugging of the guaranty, has obtained for years, as appears in the second table, which shows the excess of the average analysis over the average guaranty for five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average 10 percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

GUARANTIES, ANALYSES, SELLING PRICES AND VALUATIONS

	PERCENT GUARANTEED			PERCENT FOUND			
	Lowest	Highest	Average	Lowest	Highest	Average	Excess of average analysis over guaranty
Nitrogen,	*0.8	8.5	†2.01	0.98	8.95	†2.23	0.22
Total phos. acid,	5.	16.	9.08	6.88	16.60	10.53	1.45
Avail. phos. acid,	3.9	11.	7.53	3.65	12.18	8.32	0.79
Potash,	1.	12.	4.36	1.02	13.19	4.70	0.34
Selling price,	$22.50	$58.00	$31.43				
Valuation,	$ 9.45	$39.86	$17.19	$10.04	$43.31	$18.84	$1.65

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSES OVER GUARANTIES

	1905	1906	1907	1908	1909	Av'ge for 5 years
Nitrogen,	0.22	0.28	0.20	0.18	0.22	0.22
Total phosphoric acid,	1.49	1.58	1.21	1.24	1.39	1.45
Available phos. acid,	0.54	0.67	0.45	0.50	0.59	0.79
Potash,	0.27	0.37	0.35	0.33	0.33	0.34
Valuation,	$1.86	$2.47	$1.61	$1.69	$1.86	$1.65

While the above statement shows that the goods compare well on the average with the claims made for them, the tables on pages 156-167, not to speak of the statements on pages 131 and 132, betray the fact that within this average lie concealed a few deficiencies, as well as some failures to proportion the plant food as is promised. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guaranteed is not furnished to know that the "average" is good. It is for him to exercise care and to avoid buying such goods. Yet it should be said that *seriously* faulty fertilizers, so far as guaranty maintenance is concerned, are relatively uncommon this year.

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*No nitrogen in nine brands.

†Non-nitrogenous goods omitted; if included, average drops 0.13 percent in guaranties and 0.15 percent in actualities.

(*b*) COMPARATIVE VALUES OF FERTILIZERS OF 1908 AND 1909

Of the 141 brands of commercial fertilizers which were sampled by the station during 1908 and 1909, 122 have been selected for comparison of the characters of the goods sold under these brands in each of the two years. Only those brands have been chosen which have been sampled both years. The table shows a gain in all three ingredients, the net increase on a money basis being over two percent.

AVERAGE COMPOSITION OF FERTILIZERS IN 1908 AND 1909

Name of ingredient	1908		1909	
	Pounds in a hundred	Valuation at 1909 prices	Pounds in a hundred	Valuation at 1909 prices
Nitrogen,*	2.07	$7.87	2.14	$8.13
Soluble phosphoric acid,	4.62	3.70	4.23	4.18
Reverted phosphoric acid,	3.47	2.43	3.03	2.12
Insoluble phosphoric acid,	2.30	0.92	2.25	0.90
Total phosphoric acid,	10.39	....	10.52	....
Available phosphoric acid,	8.09	....	8.26	....
Potash,*	4.51	3.83	4.53	3.85
Total valuation per ton,		$18.75		$19.18

(*c*) COMPARATIVE VALUE OF FERTILIZERS, 1895-1909

The next table shows the average composition of the fertilizers as analyzed during the past fifteen years. Every brand tested each year is included in the comparison, each one being given equal value. It is well understood that this is not strictly a correct method of calculation, but it is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods have in the past sold slowly and, unfortunately, low grade brands as a rule readily, the

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*Nitrogen calculated as all organic; potash calculated as muriate.

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1895 TO 1909*

Year	Number of brands	Nitrogen	Soluble phosphoric acid	Reverted phosphoric acid	Insoluble phosphoric acid	Total phosphoric acid	Available phosphoric acid	Potash.
1895	92	2.22	5.84	2.56	2.23	10.93	8.40	3.46
1896	110	2.22	5.36	3.44	2.23	11.02	8.80	3.66
1897	134	2.12	5.34	3.68	2.23	11.25	9.02	3.43
1898	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81
1899	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10
1900	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80
1901	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33
1902	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21
1903	111	2.02	5.13	3.42	2.50	11.05	8.55	3.97
1904	118	1.98	5.20	3.19	2.38	10.77	8.39	3.95
1905	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18
1906	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37
1907	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65
1908	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58
1909	133	2.08	5.25	3.07	2.21	10.53	8.32	4.70

AVERAGE COST OF FERTILIZERS SOLD IN VERMONT FROM 1895 TO 1909

Year	Number of brands analyzed	Average selling price per ton	Average valuation at each year's trade values	Excess of selling price over valuation	Percentage excess of selling price over valuation	Value of plant food received for each dollar paid out	Average valuation at 1909 trade values[1]
1895	92	$30.90	$21.28	$ 9.62	45	69 cts.	$18.45
1896	110	30.90	19.73	11.17	57	64 "	18.86
1897	134	29.19	19.47	9.72	50	67 "	18.45
1898	126	29.04	17.86	11.18	63	61 "	18.92
1899	137	28.75	17.39	11.36	65	60 "	18.34
1900	132	28.73	18.08	10.65	59	63 "	18.41
1901	134	28.75	19.44	9.31	48	68 "	18.81
1902	136	28.23	20.18	8.05	40	71 "	19.29
1903	111	28.25	18.59	9.66	52	66 "	18.28
1904	118	29.00	18.47	10.53	57	64 "	17.98
1905	130	29.62	19.18	10.58	56	64 "	18.30
1906	130	29.52	19.38	10.14	52	66 "	18.75
1907	129	30.57	21.21	9.36	45	69 "	18.89
1908	130	31.24	20.75	10.49	51	66 "	18.50
1909	133	31.43	18.84	12.59	67	60 "	18.87

*See footnote (1) on succeeding page.

actual average as used is probably somewhat lower than that shown in the table on page 137[1]. Yet the evidence in hand indicates a lessened usage of low grades and a larger usage of medium and high grades to-day than formerly obtained.

The average commercial fertilizer sold in Vermont in 1909 contains the same nitrogen content, but 0.20 percent more available phosphoric acid and 0.10 percent more potash than that sold in 1908. The increase in the averages of the past five years, as compared with those of previous years, is due to the somewhat unusual character of certain goods sold for the first time in 1905, and to the entry in 1907 of several relatively high grade goods. A survey of the table indicates that no profound change has taken place during the fifteen years. Indeed there seems to be three periods of four, six and five years respectively wherein there are somewhat wide differences in the plant food content of the average goods,, particularly in phosphoric acid and potash, as shown below:

1895-98......nitrogen 2.19, available phosphoric acid 8.75, potash 3.60
1899-04......nitrogen 2.07, available phosphoric acid 8.51, potash 4.06
1905-09......nitrogen 2.08, available phosphoric acid 8.21, potash 4.50

The average grade goods are better to-day than hitherto; but that is not saying that there are not many inferior ones on the market.

At what prices did the sundry forms of available plant food sell in the average mixed fertilizer of these years?

The tendency during the last three years has been towards increased selling prices, particularly of medium and high grade goods. The recent sharp fall in the cost of nitrogenous and

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[1] It ought to be remarked at this point that neither this table, nor the table which immediately precedes it, nor the discussion of this matter, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made in 1904 to estimate the relative usage of the different grades, but without much success. No data is available that is trustworthy, while if one appeals to the individual judgment of those who are in closest touch with the trade, the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used at 1.80 to 1.90 percent nitrogen, 8.50 percent available phosphoric acid, and 3.25 to 3.50 percent potash.

COST OF PLANT FOOD IN THE AVERAGE MIXED FERTILIZER, 1895 TO 1909

Year	Number of brands analyzed	Cost of one pound of organic nitrogen	Cost of one pound of available phosphoric acid	Cost of one pound of potash (as muriate)
1895	92	23.9 cts.	8.7 cts.	6.5 cts.
1896	110	22.0 "	8.6 "	7.1 "
1897	134	21.0 "	8.3 "	6.8 "
1898	126	22.8 "	7.3 "	6.9 "
1899	137	23.1 "	7.4 "	7.0 "
1900	132	24.6 "	7.1 "	6.7 "
1901	134	23.7 "	7.4 "	6.3 "
1902	136	23.1 "	7.0 "	6.0 "
1903	111	25.9 "	6.8 "	6.5 "
1904	118	27.5 "	6.9 "	6.7 "
1905	130	28.9 "	6.8 "	6.6 "
1906	130	28.3 "	6.6 "	6.4 "
1907	129	29.6 "	6.9 "	6.1 "
1908	130	30.5 "	7.1 "	6.3 "
1909	133	31.7 "	6.3 "	7.1 "

phosphatic crude stock should tend in the future to lower prices as it has already lowered valuations.

2. AS TO QUALITY OF PLANT FOOD

(a) SOURCES OF PLANT FOOD IN LICENSED FERTILIZERS

The table on page 135 as well as those on pages 156-167, show wide ranges in composition, amounts of nitrogen varying from 0.98 to 8.95 percent, of available phosphoric acid from 3.65 to 12.18 percent, and of potash from 1.02 to 13.19 percent. These figures alone, however, do not tell the whole story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food of the various brands is derived.

NITROGEN

Ten of the twelve fertilizer manufacturers used more or less water-soluble nitrogen (as nitrate of soda or as sulphate of ammonia) in one or more of their brands. Four used it in most of their brands and have habitually done so for years; four used it in half of their nitrogenous brands; and two used it in one or two brands. More or less water-soluble nitrogen was present in 63 percent of those brands which contained nitrogen, the amounts varying from 0.20 to 7.74 percent and averaging 1.04 percent (39 percent of the total nitrogen present in these brands). Under certain circumstances and for certain purposes water-soluble nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available, but more easily lost by leaching. (See pages 89-90, bulletin 99). All the brands but one which carry nitrogen contain more or less organic nitrogen. In 37 percent of them organic nitrogen is the only form present, derived, presumedly, as a rule from standard animal and vegetable ammoniates such as dried blood, meat meal, fish scrap, tankage, cottonseed meal, etc. Probably tankage is at present its main source in the great majority of brands. It is reasonably safe to say that as a rule the sources of organic nitrogen have been of good grade.

Available nitrogen.—Every brand carrying organic nitrogen was tested by the alkaline-permanganate distillation method,[1] as has been done yearly for eleven years. This method, as has been pointed out hitherto, affords results which have comparative rather than absolute values.

The subjoined table shows the organic and total nitrogen availabilities of the average goods made by each firm as measured by this method. Each brand is given equal value in the average. The figures are arranged in the general order of their excellence, yet no stress should be laid upon the order of statement. Since the method used is empirical, firm names are omitted:

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[1] Vt. Sta. Rpts. 11, pp. 160-171 (1898); 12, pp. 137-139 (1899); 14, pp. 219-221 (1901).

	Organic nitrogen available percent	Total nitrogen available percent		Organic nitrogen available percent	Total nitrogen available percent
A	66	74	G	62	62
B	63	77	H	55	66
C	65	70	I	58	58
D	65	68	K	52	64
E	59	73	L	52	61
F	62	63	M	46	56

As to grade. The availability of the organic nitrogen of brands low therein tended as a rule to be lower than that of the medium or high class goods. This has been noted for many years. In other words the nitrogen of certain low grade brands seems to lack somewhat in quality as well as in quantity.

As to manufacture. A larger number of brands than usual were deemed open to question. Some one or more brands sold by several licensees afforded unsatisfactory analytical results. Pepsin digestion was also employed on several brands and low results attained in some cases. The outcome with several companies, however, and as ever, was all that could be desired. A possible explanation may be found in the high cost, restricted supply, and heavy demands for standard organic ammoniates, together with the marked increase in total sales of mixed goods. Whatever the cause, certain it is that grave doubts exist in the writer's mind as to the grade of some of the organic nitrogen offered for sale this year in Vermont. It is to be regretted not only that this much must be said, but also that the inability with absolute certainty to detect inferiority does not admit of more definite statement. A further study of certain brands as sold this year is planned for the near future.

PHOSPHORIC ACID

Some companies furnish more total phosphoric acid in available form than others; some, more of water soluble relative to the citrate-soluble or reverted than do others. Water-soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate-soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumina phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as valuable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 44 percent to 95 percent. The proportions of available phosphoric acid found to be in a water-soluble form varied from 18 percent to 87 percent.[1] Grouped according to their manufacture it was found that extremes for available in total were 66 and 92 percents, for water-soluble in available 49[1] and 75 percents. In other words, the average goods made by one firm carried 92 percent of the total phosphoric acid in available form, while those made by another firm furnished but 66 percent in that shape, the remainder ranging between. Similarly, on the average 75 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 49 percent was thus soluble in the average goods of another firm. The low availability seems to be due in some cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause, to imperfectly cut phosphate rock, to the age of the goods, to the use of agriculturally inferior forms of phosphoric acid, or to other causes does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, rarely, nitrate. The direct or inferential claim is made for three-fifths of the brands that sulphate of potash is used in their manufacture. This is often merely a subterfuge, is intentionally misleading, and is not borne out by the facts. It is doubtless not illegal for a manufacturer to indicate an equivalence, since such an expression is not strictly speaking a guaranty, but simply a part of that surplusage with which manufacturers are apt to bedeck fertilizer sacks. Six of the twelve companies selling in Vermont do not try thus to mislead their customers; six, however, for some or all their goods made this doubtful statement. The American Agricultural Chemical Company makes this inferential claim by the use of the phraseology "equivalent to sulphate of potash," for 58 brands; the Bowker Fertilizer Company, for 7 of 14 brands; the Lowell Fertilizer Company, for 7 of 8 brands; the Burlington Rendering Company, for 1 of 2 brands; the New England Fertilizer Company for 4 brands; and the Essex Fertilizer Company for 1 of 5 brands. Oddly enough for the four brands in which it is used, two largely and two slightly, no claim of sulphate is made. Either it is not used in a single one of the 78 brands whose makers intimate its use; or else enough chlorin is present therein in each case to neutralize its good effects, if any such there be. Only two brands out of the entire 133 carried any material quantities of sulphate of potash. Wherever the asterisk (*) appears against the station number at the left of the analysis and against the potash figures in the columns thus headed in the tables on pages 156 to 167, sulphate (or, possibly, nitrate) of potash was found to be present; where these signs do not appear the potash was derived doubtless from muriate or kainit.

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[1] Exclusive of five brands of unacidulated goods, mixtures of bone or tankage with chemicals.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for over a decade. It has been customary of late to approach the matter from two directions, to make two classifications, basing one on *cost* and the other on *value*. Three groups, somewhat arbitrarily formed, designated "low priced," "medium priced" and "high priced," furnish the means of comparing the cost, while as many groups termed "low grade," "medium grade" and "high grade" serve the purpose in the study of relative values.

When grouped according to selling prices the item of *cost* is emphasized; when the valuations govern the sub-divisions, the stress is laid upon the *worth* of the material. The selling price may or may not bear an essentially just relation to the plant food content of the fertilizer. The valuation, however, is a more exact measure. Since both cost and worth are important factors, and since some may grasp the facts more readily when presented from one viewpoint while others see the situation better when looked at from the other side, it has been deemed best to present the results of both methods of comparison. The general outcome is much the same either way the proposition is figured.

I. FROM THE STANDPOINT OF COST

The brands may be classified as to selling price as follows:

	Number of brands	Percent of total	Average selling price
Low priced, selling at $28 or below....	39	30	$26.29
Medium priced, selling from $28.50 to $32.50	54	41	29.93
High priced, selling for $33 or more...	38*	29	37.84

The average, largest and smallest values of plant food offered in the groups of brands appear below. The figures show the values of plant food bought for a dollar in the average goods of each grade, including the greatest as well as the least value obtained in any brand in each class.

VALUE OF PLANT FOOD BOUGHT FOR A DOLLAR

	Average	Smallest	Largest
Low priced	$0.53	$0.40	$0.70
Medium priced	0.58	0.40	0.74
High priced	0.65	0.49	0.74

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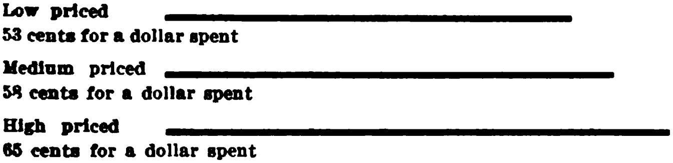
*A highly nitrogenous and relatively costly oats and top dressing and a high priced tobacco goods are omitted from the comparison.

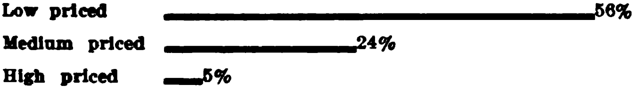
It is interesting to note the number of brands in each group which furnish less than 55 cents' worth of plant food[1] for a dollar, as well as the number which afforded more than 65 cents' worth for the same sum:

Low priced:	**Less than 55c. worth, 22;**	**more than 65c. worth, 1.**
Medium priced:	**Less than 55c. worth, 13;**	**more than 65c. worth, 7.**
High priced:	**Less than 55c. worth, 2;**	**more than 65c. worth, 20.**

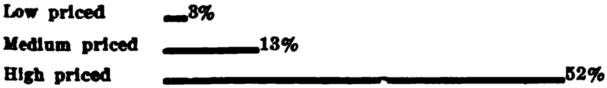
The comparisons can be shown graphically. The relative length of the following lines show the average money value in plant food at retail seaboard prices bought for a dollar at Vermont delivery points in brands selling for $28 or less (low priced), from $28.50 to $32.50 (medium priced), and for $33 and above (high priced):



The following lines show the proportion of the total number of brands in each group containing 55 cents or less worth of plant food for each dollar invested:



The final set of lines show the proportion of the total number of brands in each group containing 65 cents or more worth of plant food for each dollar invested of the purchase price:



If lines and figures are put into words, it will be seen that:

1. The same amounts of plant food which cost a dollar in

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[1] The phrase "55 cents' worth of plant food" should be construed to mean an amount of plant food which, if bought for cash at retail at the seaboard, would have cost 55 cents in standard, unmixed, raw materials.

the average low priced brands ($28 and below) might have been bought in the unmixed state at retail and at the seaboard for 53 cents; in the average medium priced goods ($28.50 to $32.50) for 58 cents; and in the average high priced goods ($33 and upwards) for 65 cents. Extremes of values were 74 and 40 cents. In more than a quarter of the brands the sums charged for manufacture, transportation, sale, etc., comprised 45 percent or more of the retail cost, thus leaving only 55 percent or even less to pay for the plant food; while in an eighth of the entire number these charges exceeded the seaboard value of the unmixed plant food.

2. In nearly three-fifths of the total number of low priced brands the charges for mixing, sale, etc., aggregate at least 45 percent of the selling price, while in only one in four of the number of medium priced brands and in but two out of thirty-eight of the high cost goods were the charges thus large.

3. Half of the total number of high class goods contained an equivalent of 65 cents or more worth of plant food at retail seaboard prices. But one in eight of the medium and one in forty of the low grade goods contain so high an equivalent.

These things are naturally so, inevitably so. There are good and sufficient reasons for this showing, which may be condensed in a nutshell as follows: It costs as much to mix, to store, to regrind, to bag, to ship, to freight, to sell, to collect for sales, etc., a ton carrying 1,200 pounds of genuine fertilizer and 800 pounds of mere filler (diluent) as one that contains 2000 pounds of undiluted fertilizer ingredients. Therefore the buyer of low grade goods must pay for all this useless handling of the nearly or quite worthless filler. It is an old story, reiterated year after year, but it is one which needs to be told as long as material usage of low grade brands obtains.

2. FROM THE STANDPOINT OF VALUE

Let us now turn the matter about and study it from the standpoint of *worth*. The figures and proportions naturally differ from those just presented. The brands may be classified as to valuation as follows:

	Number of brands	Percent of total	Average valuation
Low grade, valuing at $15.50 or less......	42	32	$13.52
Medium grade, valuing at $15.51 to $22..	59	45	18.22
High grade, valuing at $22.01 and upwards	29[1]	23	26.30

The composition, selling price and valuation of the average brand of each group appears below:

	Nitrogen	Available phosphoric acid	Potash	Total plant food, pounds	Average selling price	Average valuation	Selling price exceeds valuation by
Low grade,	0.99	9.00	2.53	12.5	$27.10	$13.52	$13.58
Medium grade,	2.34	8.55	4.30	15.2	30.00	18.22	11.78
High grade,	3.19	7.52	9.06	19.8	38.93	26.30	12.63

A survey of this table indicates that:

1. The proportion of nitrogen increases in regular graduations from group to group; that of phosphoric acid drops one-half percent from the lower to the medium and one and one-half percent in the high grade goods; while the potash increases nearly two percent in the medium and over six and one-half percent in the high grade brands, as compared with the lower ones.

2. The low grade goods carry nine times as much phosphoric acid as they do of nitrogen and nearly four times as much phosphoric acid as they do of potash. These proportions become, roughly, four and two in the medium grade. In the high grade fertilizers there are but two and one-third times as much phosphoric acid as nitrogen, and one and one-half percent more potash than phosphoric acid. The latter grade more closely resembles the proportions commonly present in the crops ordinarily grown than do either of the other grades.

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[1] Exclusive of three brands, a highly nitrogenous and relatively costly oats and top dressing, and a high priced tobacco goods, valuations of which are relatively very high, and a lawn dressing milled extra fine and sold on that account at an advance in price.

A study of the main tables and of the data in hand further shows that nine out of ten high grade goods and three out of four medium grade brands contained either nitrate or ammonia salts (water-soluble nitrogen). Only one brand in five or nine in the entire forty-two of the low grades contained this valuable form of plant food; and five of these nine contained each less than 5 pounds to a ton and but one more than 10 pounds per ton. Moreover, the organic nitrogen availability of the low grade goods tended to run somewhat lower than that of the better classes,

3. The medium grade goods for one-ninth advance in price over the cost of the low grade brands offer an eighth more plant food and three-eighths more commercial value.

4. The high grade fertilizers for three-sevenths advance in price over the cost of the low class goods furnish four-sevenths more plant food and almost double the commercial value.

5. The higher the grade the less the margin between cost and worth, both actually and relatively. In buying the average low grade brand one paid this year $13.58 for service of one sort or another (factory and office charges, freight, selling expenses, etc.) incurred in the delivery of $13.52 worth of plant food; when medium grade goods were bought, $11.78 service charges placed $18.22 worth of plant food in the buyer's hands; and when high grade goods are bought $12.63 service charges placed $26.30 worth of plant food in the buyer's hands. Or, phrasing the matter another way,

THE COST OF PLACING A DOLLAR'S WORTH OF PLANT FOOD IN THE FARMER'S HANDS WAS:

In low grade goods	one dollar
In medium grade goods	65 cents
In high grade goods	48 cents

It may be worth while now to scan the prices paid for a pound of nitrogen, of available phosphoric acid and of potash in the several grades. The next table shows this, including the average, lowest and highest costs as well as the retail cash cost of these ingredients in Boston or New York, or, in other words, their "valuations." (See pages 67-69 this bulletin, and pages 81-86, bulletin 99).

COST OF A POUND OF PLANT FOOD IN FERTILIZERS OF VARIOUS GRADES[1]

	NITROGEN			AVAILABLE PHOSPHORIC ACID			POTASH		
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
					cts.				
Low grade,	38.0	47.0	32.3	7.6	9.4	6.5	8.5	10.5	7.2
Medium grade,	31.3	25.6	38.9	6.3	5.1	7.8	7.0	5.7	8.7
High grade,	28.3	30.6	25.6	5.7	6.2	5.1	6.3	6.8	5.7
Retail cost, Boston or New York,	19.			3.82			4.25		

The same lesson enforced in a different way, that cheap fertilizers are the most costly. Some Vermont buyers paid 47 cents for a pound of nitrogen which they might have bought for 25½ cents laid down at their doors in mixed fertilizers. They paid under similar circumstances 9½ cents a pound instead of 5 cents for phosphoric acid and 10½ cents for potash instead of 5½ cents. They paid almost double prices because they did not give the matter attention, or, perhaps, because they did not believe in "book farming." The thoughtful buyer of high class goods, sold at not overhigh prices, bought plant food at figures not much in advance of valuations plus freight rates.

This situation can perhaps be put more clearly and forcibly as follows. It should be clearly understood, however, that the remarks have reference solely to commercial considerations; that is to say to the buying of plant food.

The best purchase of low grade goods made on the Vermont market this year, that is to say the one wherein the buyer received the most plant food for his money, was a poorer trade than was the average buying of medium grade goods or than was the worst trade made in high grade goods.

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[1] Exclusive of brands mentioned in footnote on page 135.

The worst trade made in medium grade goods was almost as good a purchase as was the average trade in low grade brands.

The worst trade in high grade goods was a better trade than the average purchase made of medium grade goods and it was a better trade than was the best made in low grade brands.

It ought to be said in this connection that the same brands similarly named, in different localities, as well as the same goods variously named in one locality or, indeed, in one dealer's hands, are sometimes found to sell at very different prices, and, apparently, without good reason. A few very exorbitant charges have been noted. Moreover, purchasers often fail to exercise good judgment in their choices and pay overhigh charges owing to lack of information as to what to buy and how to buy it. That this situation is largely their own fault can justly be claimed, since the State has thrown about this trade safeguards which are lacking with almost every other class of traffic. The yearly fertilizer inspection, the publication of the results of the work, the free distribution of the bulletins, the clear and concise statements as to the brands on sale, the simplicity and directness of the few fundamental facts which are the main guides as to choice and to purchase; all these are ample justification of the statement that, speaking in general terms, he who is dissatisfied with the results attained with fertilizers has himself to thank for it. This dissatisfaction may be due to unwise choice, that is to say the purchase of a goods ill-adapted to a specific purpose; or, it may arise from the realization that one has paid an unreasonably high price in view of the grade of the goods. In either case a repetition of the experience may be avoided by the exercise of a little care as to choice. Particularly in the matter of purchase there often appears to be but little relation between price and plant food content. Thus, for example, goods guaranteed to carry uniform available phosphoric acid contents, but the highly variable nitrogen and potash contents noted below were found selling at a uniform price at points where freight rates were not materially unlike:

Nitrogen, 33 lbs.;	potash, 40 lbs.;	nitrogen and potash, 73 lbs.
Nitrogen, 41 lbs.;	potash, 30 lbs.;	nitrogen and potash, 71 lbs.
Nitrogen, 16 lbs.;	potash, 80 lbs.;	nitrogen and potash, 96 lbs.
Nitrogen, 41 lbs.;	potash, 60 lbs.;	nitrogen and potash, 101 lbs.

Occasionally two brands of the same make with identical nitrogen and phosphoric acid guaranties but with different potash guaranties (1.5 and 3 percents) were found sold at a flat price. That is to say a local agent will offer a corn fertilizer at $30 and a potato phosphate at $30, each containing equal amounts of nitrogen and phosphoric acid, but the latter twice as much potash as the former. This is no sin; neither is it against the law. But what well-informed buyer would choose the corn goods in preference to the potato brand?

Identical but differently named goods were sometimes sold by one and the same agent at different prices. Again, two brands with similar nitrogen and phosphoric acid guaranties but different potash figures were sold by the same agent at different prices, the higher price being asked for the lower guarantied goods.

The non-nitrogenous brands, nine of which are licensed, being relatively cheap are quite popular and somewhat widely sold. As a class they carry costly plant food. As sold this year in this State excluding one brand they average to offer only 46 cents' worth of plant food for a dollar. The excepted brand, however, offered 70 cents' worth. When one has ample home supplies of nitrogen, non-nitrogenous goods may prove advisable purchases; but commercially they are usually expensive plant food.

3. AS BETWEEN MANUFACTURERS

One company averaged to charge 48 cents for placing a dollar's worth of plant food in the buyer's hands. Yet another asked twice as much or 96 cents for the same service. In the one case a dollar bought 67 cents' worth of plant food, in the other 51 cents' worth. For more than half of the brands offered by each of two companies was asked a dollar or more for the laying down of a dollar's worth of plant food at the buyer's depot; or stating it another way, the buyer of their low priced brands paid from $1.96 to $2.49 and received therefor a dollar's worth of plant food. His neighbors paid in some cases as low as $1.33 for a dollar's worth. Which made the wiser purchase? It is not difficult for anyone to apply this test before purchase. Thus, for example: Selling price, $30; guaranty, nitrogen 2%; soluble, reverted and insoluble phosphoric acids, 6, 3 and 1%s; potash, 3%; 2 x 20 x .19 = 7.60.[1] 6 x 20 x .04 = 4.80. 3 x 20 x .035 = 2.10. 1 x 20 x .02=0.40. 3 x 20 x .0425=2.55. $7.60+$4.80+$2.10+$0.40 + $2.55 = $17.45. 17.45 ÷ 30 = 58[2]; or 30 ÷ 17.45 = 1.72.[3] Seventy two cents' service charge for a dollar's worth of plant food. Fifty eight cents' worth of plant food for a dollar spent.

V. ANALYSES OF LICENSED FERTILIZERS[4]

AMERICAN AGRICULTURAL CHEMICAL Co., New York, N. Y.

D 1. *Grass and Lawn Top Dressing;* Bennington.

H 5. *Grass and Oats Fertilizer;* Bradford.

F 6. *Northwestern Challenge Crop Grower;* Irasburg.

(H. J. Baker & Co. brands.)

D15. *Standard UnXlD;* Pittsford.

(Bradley Fertilizer Co. brands.)

H 4. *Alkaline Bone and Potash;* Bennington.

G 6. *Complete Manure for Potatoes and Vegetables;* Bellows Falls.

D 9. *Complete Manure with Ten Percent Potash;* Hardwick.

D 7. *Eclipse Phosphate;* Cambridge.

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[1] I. E. 2% (or 2 lbs. per 100) nitrogen, multiplied by 20 hundreds in a ton, multiplied by the trade value of a pound of nitrogen $0.19, equals the valuation of the guaranty of nitrogen, $7.60. The other calculations are similar.

[2] Valuation divided by cost equals worth of plant food per dollar spent.

[3] Cost divided by valuation indicates service charge paid for a dollar's worth of plant food bought.

[4] Descriptions of samples analyses of which were first printed in Bulletin 140 occur therein and are not repeated here.

D10. *Niagara Phosphate;* Vergennes.
D 8. *Potato Manure;* Plainfield.

(*Clark's Cove Fertilizer Co. brands.*)

F 7. *Bay State Fertilizer G. G.;* Orleans.
F 8. *Potato Fertilizer;* Orleans.

(*Cleveland Dryer Co. brands.*)

D12. *Fertilizer for All Crops;* Enosburg.

(*Crocker Fertilizer and Chemical Co. brands.*)

D16. *Potato Special;* Barton.

(*Cumberland Bone Phosphate Co. brands.*)

G13. *Guano;* Starksboro.

(*Great Eastern Fertilizer Co. brands.*)

F12. *Garden Special;* Bridport.
F13. *General Fertilizer;* Milton.

(*Pacific Guano Co. brands.*)

F14. *Nobsque Guano;* Newport.

(*Quinnipiac Co. brands.*)

E13. *Climax Phosphate;* Montpelier.
E14. *Market Garden Manure;* Brattleboro.

(*Reed Fertilizer Co. brands.*)

G17. *High Grade Farmers Friend Superphosphate;* S. Burlington.
G 2. *Leader Blood and Bone;* Albany.
G 1. *Practical Potato Special;* Ferrisburg.
H 7. *Sure Catch Phosphate;* Randolph.

(*H. F. Tucker Co. brands.*)

E16. *Imperial Bone Phosphate for All Crops;* Hardwick.

(*Williams and Clark Fertilizer Co. brands.*)

G 3. *Americus High Grade Special;* Essex Junction.
F 5. *Americus Potato Phosphate;* Barre.
G12. *Royal Bone Superphosphate for All Crops;* Ferrisburg.

ARMOUR FERTILIZER CO., Baltimore, Md.

G16, J1, J2, Complete Manure; Bellows Falls and West Brattleboro.

G15, J3, J4, Corn Special; Bellows Falls and West Brattleboro.

G14, J5, J6, High Grade Potato; Bellows Falls and West Brattleboro.

H9, J9, Oats and Clover Special; Bellows Falls and West Brattleboro.

BOWKER FERTILIZER CO., Boston, Mass.

G 7. Market Garden Fertilizer; Rutland.

G 5. Potash Bone; Richmond.

D 2. Potash and Staple Phosphate; Norwich.

D 5. Potato and Vegetable Fertilizer; Wallingford.

G 4. Square Brand Bone and Potash; Woodstock.

D4, E17. Stockbridge Manure for Corn, Grain and Fodder Corn; Castleton.

D 3. Stockbridge Manure for Quick Growth (top dressing); Castleton.

BUFFALO FERTILIZER CO., Buffalo, N. Y.

H 3. Extra Bone and Potash; Montpelier.

D11. Fish Guano; Bristol.

H 2. General Crop; Concord.

BURLINGTON RENDERING CO., Burlington, Vt.

F11. Animal Fertilizer; Bellows Falls.

F10. Special Potato; Bellows Falls.

COE-MORTIMER CO., New York, N. Y.

F 9. Gold Brand Excelsior Guano; Montpelier.

D13. New Englander Special Corn Fertilizer; Dorset.

D14. New Englander Special Potato Fertilizer; Hartland.

H 1. Prize Brand Grass and Grain; Dorset.

ESSEX FERTILIZER CO., Boston, Mass.

E 4. A1 Superphosphate; Brandon.

E 3. Complete Manure for Corn, Grain, and Grass; Randolph.

E 1. *Grass and Grain Fertilizer;* Essex Junction.
E 2. *Market Garden and Potato Manure;* Clarendon.

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

H 6. *Animal Bone and Potash No. 2;* Woodstock.
E 8. *Grass and Oats Fertilizer;* Saxton's River.
E 9. *Oneida Special;* Woodstock.
E10. *Special Potato Fertilizer;* East Fairfield.
E11. *Special Ten Percent Potato Fertilizer;* Chester.

LOWELL FERTILIZER CO., Boston, Mass.

E 6. *Bone Fertilizer for Corn and Grain;* Montpelier.
E 7. *Cereal Fertilizer;* Enosburg Falls.
E 5. *Potato Phosphate;* New Haven Junction.

NEW ENGLAND FERTILIZER CO., Boston, Mass.

E12. *Corn and Grain Fertilizer;* Concord.
F 1. *Corn Phosphate;* Ira.

PARMENTER AND POLSEY FERTILIZER CO., Boston, Mass.

G19. *Aroostook Special;* Springfield.
G10. *Grain Grower Brand;* Springfield.
G20. *Maine State;* Springfield.
F15. *Plymouth Rock Brand;* Middlesex.
G11. *Potato Fertilizer;* Springfield.
F16. *Potato Grower with Ten Percent Potash;* Middlesex.
G18. *Special Potato Fertilizer;* Springfield.
G 9. *Star Brand Superphosphate;* Springfield.

ROGERS AND HUBBARD CO., Middletown, Conn.

F 3. *Grass and Grain Fertilizer;* Ira.
F 2. *Soluble Potato Manure;* Woodstock.
G8, J12. *Soluble Tobacco Manure;* Springfield.

ANALYSES OF LICENSED FERTILIZERS

Station Number		BRAND	Nitrogen					Phosphoric Acid								Potash		
											Total		Available					
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
D	1	A. A. C. Co. Grass and Lawn Top Dr.	4.09	0.14	4.23	*3.91*	§14.03	1.36	4.58	2.08	8.02	*6.*	5.94	*5.*	$5.13	3.14	*2.*	$2.67
H	5	A. A. C. Co. Grass and Oats Fertilizer	......	......	......	......	......	7.88	4.25	1.61	13.74	*12.*	12.13	*11.*	9.92	1.95	*2.*	1.66
A	1	A. A. C. Co. High Grade Ten Percent	1.79	1.51	3.30	*2.4*	11.65	4.76	2.08	2.48	9.32	*7.*	6.84	*6.*	6.27	10.09	*10.*	8.57
F	6	A. A. C. Co. No. West Chal. Crop. Prod	......	1.18	1.18	*1.03*	4.48	6.92	2.99	2.43	12.34	*9.*	9.91	*8.*	8.60	2.36	*2.*	2.01
A	19	A. A. C. Co. Baker's Complete Potato	1.51	1.89	3.40	*3.3*	12.16	5.36	1.50	1.46	8.32	*7.*	6.86	*6.*	5.92	10.18	*10.*	8.65
C	4	A. A. C. Co. Baker's Harvest Home....	......	1.26	1.26	*1.03*	4.79	6.20	3.08	2.00	11.28	*10.*	9.28	*8.*	7.92	2.24	*2.*	1.90
D	15	A. A. C. Co. Baker's Stand UnXlD.....	......	1.75	1.75	*1.65*	6.65	6.84	2.76	2.92	12.52	*10.*	9.60	*8.*	8.57	2.35	*2.*	2.00
H	4	A. A. C. Co. Bradley's An. Bone & Pot	......	......	......	......	......	7.64	3.93	2.29	13.86	*12.*	11.57	*11.*	9.78	2.20	*2.*	1.87
G	6	A. A. C. Co. Bradley's Com. Pot. Veg.	1.67	1.63	3.30	*3.3*	11.70	5.28	2.36	2.74	10.38	*9.*	7.64	*8.*	6.97	6.90	*7.*	5.86
D	9	A. A. C. Co. Bradley's Com. Ten Pct...	1.58	1.68	3.26	*3.3*	11.59	5.32	2.18	2.18	9.68	*7.*	7.50	*6.*	6.66	9.99	*10.*	8.49
A	8	A. A. C. Co. Bradley's Corn Phos......	0.81	1.79	2.60	*2.06*	9.47	6.48	2.91	2.99	12.38	*10.*	9.39	*8.*	8.42	2.17	*1.5*	1.84
D	7	A. A. C. Co. Bradley's Eclipse Phos...	......	1.31	1.31	*1.03*	4.98	7.16	2.42	2.94	12.52	*10.*	9.58	*8.*	8.60	2.48	*2.*	2.11

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
D 10	A. A. C. Co. Bradley's Niagara Phos..	......	1.12	1.12	*0.82*	$4.26	3.36	4.65	2.55	10.56	*8.*	8.01	7.	$6.97	1.60	*1.*	$1.36
A 5	A. A. C. Co. Bradley's Potato Fert....	0.84	1.33	2.17	*2.06*	7.82	6.04	3.38	2.94	12.36	*10.*	9.42	*8.*	8.38	2.97	*3.*	2.52
D 8	A. A. C. Co. Bradley's Potato Manure	1.47	1.44	2.91	*2.5*	10.32	2.36	3.72	2.76	8.84	*8.*	6.08	*6.*	5.59	4.98	*5.*	4.23
A 7	A. A. C. Co. Bradley's Vermonter......	(a) 0.67	1.75	2.42	*2.06*	8.90	6.32	2.02	2.32	10.66	*10.*	8.34	*8.*	7.40	3.09	*3.*	2.63
A 6	A. A. C. Co. Bradley's XL Superphos	0.81	1.65	2.46	*2.5*	8.94	7.24	2.00	2.32	11 56	*11.*	9.24	*9.*	8.12	2.28	*2.*	1.94
F 7	A. A. C. Co. Clark's Cove Bay State....	(b) 0.67	1.65	2.32	*2.06*	8.53	5.92	2.06	2.34	10.32	*10.*	7.98	*8.*	7.12	1.88	*1.5*	1.60
C 1	A. A. C. Co. Clark's Cove King Philip	......	1.26	1.26	*1.03*	4.79	5.66	2.68	2.42	10.76	*10.*	8.34	*8.*	7.38	2.22	*2.*	1.89
F 8	A. A. C. Co. Clark's Cove Potato Fert.	0.28	2.11	2.39	*2.06*	8.94	5.96	2.14	2.90	11.00	*10.*	8.10	*8.*	7.43	3.27	*3.*	2.78
D 12	A. A. C. Co. Cleveland Fertilizer.	......	1.14	1.14	*1.03*	4.33	6.60	2.70	2.10	11.40	*10.*	9.30	8.	8.01	2.24	*2.*	1.90
A 12	A. A. C. Co. Cleveland Potato Phos....	0.74	1.50	2.24	*2.06*	8.14	6.38	2.78	2.48	11.64	*10.*	9.16	8.	8.04	3.47	*3.*	2.95
A 13	A. A. C. Co. Cleveland Superphos......	(c) 0.98	1.26	2.24	*2.06*	8.11	6.40	2.26	2.10	10.76	*10.*	8.66	*8.*	7.54	2.12	*1.5*	1.80

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.
(a) As nitrates, 0.28 percent; as ammonia salts, 0.39 percent.
(b) As nitrates, 0.20 percent; as ammonia salts, 0.47 percent.
(c) As nitrates, 0.15 percent; as ammonia salts, 0.83 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen					Phosphoric Acid								Potash		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
A 17	A. A. C. Co. Crocker's Am. Corn Phos.	0.81	1.54	2.35	*2.06*	$8.52	6.68	2.42	2.26	11.36	*10.*	9.10	*8.*	$7.93	1.90	*1.5*	$1.61
A 16	A. A. C. Co. Crocker's New Rival.	0.20	0.96	1.16	*1.03*	4.31	6.76	2.58	2.18	11.52	*10.*	9.34	*8.*	8.10	2.21	*2.*	1.88
A 18	A.A.C.Co. Crocker's Pot. Hop & Tob...	0.84	1.44	2.28	*2.06*	8.24	6.60	2.49	2.95	12.04	*10.*	9.09	*8.*	8.20	3.19	*3.*	2.71
D 16	A. A. C. Co. Crocker's Potato Special..	1.68	2.07	3.75	*3.3*	13.41	5.42	2.16	1.38	8.96	*7.*	7.58	*6.*	6.40	9.84	*10.*	8.36
G 13	A. A. C. Co. Cumberland Guano.........	§0.21	1.16	1.37	*1.03*	5.12	4.28	4.42	2.38	11.08	*10.*	8.70	*8.*	7.46	1.93	*2.*	1.64
C 3	A. A. C. Co. Cumberland Potato..	0.70	1.54	2.24	*2.06*	8.16	6.14	3.10	1.92	11.16	*10.*	9.24	*8.*	7.85	3.36	*3.*	2.86
C 2	A. A. C. Co. Cumberland Superphos....	§0.86	1.46	2.32	*2.06*	8.47	6.58	2.10	2.08	10.76	*10.*	8.68	*8.*	7.56	2.32	*1.5*	1.97
A 20	A. A. C. Co. Darling's Farm Favor....	§0.87	1.37	2.24	*2.06*	8.16	6.96	1.70	1.98	10.64	*10.*	8.66	*8.*	7.55	3.17	*3.*	2.69
C 16	A. A. C. Co. Darling's General Fert...	0.74	0.94	1.68	*1.25*	6.01	4.66	2.92	2.38	9.96	*7.*	7.58	*6.*	6.73	4.18	*3.*	3.55
F 12	A. A. C Co. Gr. East. Garden Special	1.93	1.63	3.56	*3.3*	12.56	3.12	4.00	2.92	10.04	*9.*	7.12	*8.*	6.47	7.63	*7.*	6.49
F 13	A. A. C. Co. Gr. East. General...........	......	1.18	1.18	*0.82*	4.48	4.84	3.15	2.85	10.84	*10.*	7.99	*8.*	7.22	4.05	*4.*	3.44
B 3	A. A. C. Co. Gr. East. Nor. Corn Spec...	0.63	1.65	2.28	*2.06*	8.35	5.96	2.51	2.63	11.10	*10.*	8.47	*8.*	7.61	1.75	*1.5*	1.49

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number		BRAND	Nitrogen					Phosphoric Acid								Potash		
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
											Found	Guar.	Found	Guar.				
B	4	A. A. C. Co. Gr. East. Potato Manure	0.67	1.50	2.17	*2.06*	$7.91	4.72	3.89	3.29	11.90	*10.*	8.61	*8.*	$7.80	3.04	*3.*	$2.58
F	14	A. A. C. Co. Pac. Gu. Co. Nobsque Gu.	......	1.11	1.11	*1.03*	4.22	7.04	2.52	2.50	12.06	*10.*	9.56	*8.*	8.39	2.02	*2.*	1.72
B	12	A. A. C. Co. Pac. Gu. Co. Potato Spec.	0.28	1.96	2.24	*2.06*	8.37	6.20	1.94	2.84	10.98	*10.*	8.14	*8.*	7.46	3.34	*3.*	2.84
B	13	A. A. C. Co. Pac. Gu. Co. Sol. Pac. Gu.	(d) 0.60	1.50	2.10	*2.06*	7.70	5.64	2.36	2.52	10.52	*10.*	8.00	*8.*	7.17	1.77	*1.5*	1.50
E	13	A. A. C. Co. Quinnipiac Climax Phos.	§ 0.25	1.10	1.35	*1.03*	5.03	3.68	4.70	3.20	11.58	*10.*	8.38	*8.*	7.51	2.36	*2.*	2.01
B	15	A. A. C. Co. Quinnipiac Corn Manure	§ 0.81	1.36	2.17	*2.06*	7.92	6.28	2.75	1.93	10.96	*10.*	9.03	*8.*	7.71	2.18	*1.5*	1.85
E	14	A. A. C. Co. Quinnipiac Market Gard.	(e) 1.84	1.55	3.39	*3.3*	12.01	5.08	3.18	3.58	11.84	*9.*	8.26	*8.*	7.72	7.72	*7.*	6.56
B	14	A. A. C. Co. Quinnipiac Potato Phos.	0.84	1.40	2.24	*2.06*	8.09	6.52	2.57	3.35	12.44	*10.*	9.09	*8.*	8.35	3.08	*3.*	2.62
C	5	A. A. C. Co. Read's Farmer's Friend.	0.70	1.58	2.28	*2.06*	8.31	6.26	2.52	2.46	11.24	*10.*	8.78	*8.*	7.75	3.18	*3.*	2.70
G	17	A. A. C. Co. Read's H. G. F. Friend..	1.72	1.60	3.32	*3.3*	11.76	3.96	2.89	2.21	9.06	*7.*	6.85	*6.*	6.07	10.06	*10.*	8.55
G	2	A. A. C. Co. Read's Leader Blo. & Bo.	§ 0.21	0.91	1.12	*0.82*	4.17	3.52	3.86	3.10	10.48	*8.*	7.38	*7.*	6.76	1.02	*1.*	0.87

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.
(d) As nitrates, 0.34 percent; as ammonia salts, 0.26 percent.
(e) As nitrates, 1.42 percent; as ammonia salts, 0.42 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number		BRAND	Nitrogen					Phosphoric Acid								Potash		
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
G	1	A. A. C. Co. Read's Prac. Potato Spec.	. ....	1.04	1.04	*0.82*	$3.95	4.24	3.20	2.46	9.90	*5.*	7.44	*4.*	$6.61	8.08	*8.*	$6.87
B	16	A. A. C. Co. Read's Standard Superph.	......	1.16	1.16	*0.82*	4.41	4.92	3.28	2.52	10.72	*10.*	8.20	*8.*	7.25	4.09	*4.*	3.48
H	7	A. A. C. Co. Read's Sure Catch Phos.	......	......	......	......	......	8.00	3.99	2.01	14.00	*11.*	11.99	*10.*	9.99	2.10	*2.*	1.78
E	15	A. A. C. Co. Tucker's Imp. for all Crops	.. ..	1.30	1.30	*1.03*	4.94	6.64	2.55	3.25	12.44	*10.*	9.19	*8.*	8.42	2.59	*2.*	2.20
B	19	A. A. C. Co. Tucker's Imp. for Corn..	......	1.33	1.33	*1.03*	5.05	4.50	4.14	2.44	11.08	*10.*	8.64	*8.*	7.47	2.04	*2.*	1.73
E	16	A. A. C. Co. Tucker's Imp. for Potatoes	§0.21	1.26	1.47	*1.03*	5.50	4.36	4.18	3.28	11.82	*10.*	8.54	*8.*	7.74	2.30	*2.*	1.96
B	20	A. A. C. Co. W. & C. Co.'s Am. Corn Phos.	§0.83 (f)	1.31	2.14	*2.06*	7.80	6.76	2.09	2.25	11.10	*10.*	8.85	*8.*	7.77	2.09	*1.5*	1.78
G	3	A. A. C. Co. W. & C. Co.'s H. G. Spec.	1.86	1.49	3.35	*3.3*	11.88	5.20	2.92	3.10	11.22	*9.*	8.12	*8.*	7.44	6.77	*7.*	5.75
C	6	A. A. C. Co. W. & C. Co.'s Potato Man.	0.60 (g)	1.68	2.28	*2.06*	8.36	6.02	3.14	1.96	11.12	*10.*	9.16	*8.*	7.81	3.38	*3.*	2.87
F	5	A. A. C. Co. W. & C. Co.'s Pot. Phos.	1.51	1.28	2.79	*2.5*	9.86	1.68	4.69	2.33	8.70	*8.*	6.37	*6.*	5.55	4.84	*5.*	4.11
C	7	A. A. C. Co. W. & C. Co.'s Prol. Crop Prod.	0.28	0.91	1.19	*0.82*	4.38	3.34	4.16	2.22	9.72	*8.*	7.50	*7.*	6.47	1.67	*1.*	1.44
G	12	A. A. C. Co. W. & C. Co.'s Roy. Bone	......	1.26	1.26	*1.03*	4.79	3.08	6.01	5.35	14.44	*10.*	9.09	*8.*	8.81	2.03	*2.*	1.73

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.
(f) As nitrates, 1.00 percent; as ammonia salts, 0.86 percent.
(g) As nitrates, 1.30 percent; as ammonia salts, 0.21 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
†G. 16	Armour Fert. Co.'s Complete Manure	0.50	1.50	2.00	*3.3*	$7.35	5.24	1.85	0.83	7.92	7.	7.09	*6.*	$5.81	†12.25	*10.*	$10.72
†J 2	Armour Fert. Co.'s Complete Manure	0.70	1.92	2.62	*3.3*	9.61	6.44	0.98	0.62	8.04	7.	7.42	*6.*	6.07	†8.86	*10.*	7.90
†J 1	Armour Fert. Co.'s Complete Manure	0.84	2.37	3.21	*3.3*	11.78	3.72	2.80	0.68	7.20	7.	6.52	*6.*	5.21	†10.14	*10.*	8.75
G 15	Armour Fert. Co.'s Corn Special.......	......	1.40	1.40	*1.65*	5.32	5.84	1.63	0.63	8.10	*8.5*	7.47	*8.*	6.07	6.42	*5.*	5.46
J 4	Armour Fert. Co.'s Corn Special........	......	1.32	1.32	*1.65*	5.02	4.08	3.22	0.72	8.02	*8.5*	7.30	*8.*	5.80	6.96	*5.*	5.91
J 3	Armour Fert. Co.'s Corn. Special	......	1.28	1.28	*1.65*	4.86	4.84	3.90	0.74	9.48	*8.5*	8.74	*8.*	6.90	5.16	*5.*	5.38
†G 14	Armour Fert. Co.'s High Gr. Potato...	......	1.76	1.76	*1.65*	6.67	6.28	1.25	0.87	8.40	*10.*	7.53	*8.*	6.25	†10.23	*10.*	8.98
†J 6	Armour Fert. Co.'s High Gr. Potato..	......	1.51	1.51	*1.65*	5.74	4.84	4.44	0.62	9.90	*10.*	9.28	*8.*	7.23	†8.88	*10.*	7.75
†J 5	Armour Fert. Co.'s High Gr. Potato..	§0.56	1.30	1.86	*1.65*	6.84	6.16	3.68	0.96	10.80	*10.*	9.84	*8.*	7.89	†10.35	*10.*	8.94
H 9	Armour Fert. Co.'s Oats and Clover...	0.53	0.17	0.70	.....	2.36	7.16	2.15	0.33	9.64	......	9.31	*10.*	7.37	8.14	*8.*	6.92
J 8	Armour Fert. Co.'s Oats and Clover...	0.74	0.42	1.16	......	4.11	4.96	3.82	0.64	9.42	.....	8.78	*10.*	6.90	6.63	*8.*	5.63
J 9	Armour Fert. Co.'s Oats and Clover...	......	......	......	.....	......	7.20	4.60	4.80	16.60	.....	11.80	*10.*	10.90	8.08	*8.*	6.87

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.
†Potash partly as sulphate.
Note. Concerning these analyses see text, pages 131-132. J1, J3, J5, J9, were taken at West Brattleboro, the others at Bellows Falls.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
										Total		Available					
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
A 2	Bowker's Corn Phosphate................	0.63	1.16	1.79	*1.65*	$6.49	4.40	3.70	3.96	12.06	*9.*	*8.10	*8.*	$7.70	2.29	*2.*	$1.95
C 11	Bowker's Hill and Drill Phosphate....	0.74	2.00	2.74	*2.47*	10.04	6.36	3.54	2.82	12.72	*10.*	9.90	*9.*	8.70	2.04	*2.*	1.73
G 7	Bowker's Market Garden Fertilizer...	0.72	1.77	2.49	*2.47*	9.11	3.52	2.22	2.48	8.22	*8.*	5.74	*6.*	7.36	11.19	*10.*	9.51
G 5	Bowker's Potash Bone.........	......	1.14	1.14	*0.82*	4.33	6.56	2.52	2.48	11.56	*8.*	9.08	*6.*	8.00	2.26	*2.*	1.92
D 2	Bowker's Potash or StaplePhosphate	......	1.25	1.25	*0.82*	4.75	6.76	2.44	2.88	12.08	*9.*	9.20	*8.*	8.27	4.80	*3.*	4.08
D 5	Bowker's Potato and Vegetable Fert..	1.05	1.62	2.67	*2.47*	9.63	6.00	3.22	2.22	11.44	*9.*	9.22	*8.*	7.94	3.84	*4.*	3.26
A 3	Bowker's Potato and Vegetable Phos.	0.49	1.30	1.79	*1.65*	6.56	4.60	3.43	4.01	12.04	*10.*	8.03	*8.*	7.68	2.24	*2.*	1.90
G 4	Bowker's Square Brand Bone and Pot.	§0.20	1.78	1.98	*1.65*	7.44	4.56	3.29	3.95	11.80	*7.*	7.85	*6.*	7.53	1.96	*2.*	1.67
D 4 E 17	Bowker's Stockbridge Corn and Grain	1.51	2.17	3.68	*3.29*	13.23	3.25	5.50	3.66	12 41	......	8.75	*10.*	7.91	7.04	*7.*	5.98
A 4	Bowker's Stockbridge Potato Manure	1.58	1.82	3.40	*3.29*	12.13	5.36	1.54	1.96	8.86	*7.*	6.90	*6.*	6.16	9.98	*10.*	8.48
D 3	Bowker's Stockbridge Top Dressing	3.28	1.49	4.77	*4.93*	16.48	4.88	2.89	2.43	10.20	*6.*	7.77	*4.*	6.89	6.60	*6.*	5.61
H 8	Bowker's Superphos with Potash....	......	......	......	......	......	7.96	3.38	1.38	12.72	*11.*	11.34	*10.*	9.29	1.80	*2.*	5.30

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	Nitrogen: From Nitrates	Nitrogen: From Organic Matter	Nitrogen: Total Found	Nitrogen: Total Guaranteed	Nitrogen: Valuation of Nitrogen‡	Phosphoric Acid: Soluble	Phosphoric Acid: Reverted	Phosphoric Acid: Insoluble	Phosphoric Acid: Total Found	Phosphoric Acid: Total Guar.	Phosphoric Acid: Available Found	Phosphoric Acid: Available Guar.	Phosphoric Acid: Valuation of Phosphoric Acid‡	Potash: Found	Potash: Guaranteed	Potash: Valuation of Potash‡
D 6	Bowker's Sure Crop Phosphate.........	......	1.08	1.08	*0.82*	$4.10	6.96	2.48	2.72	12.16	*9.*	9.44	*8.*	$8.39	2.37	*2.*	$2.01
C 10	Bowker's Vt. Grange Chem. D. Brand	§0.84	1.48	2.32	*2.06*	8.47	6.22	2.08	2.06	10.36	*9.*	8.30	*8.*	7.26	3.24	*3.*	2.75
A 10	Buffalo Fert. Co.'s Celery & Pot. Spec.	(h) 0.95	0.70	1.65	*1.64*	5.87	4.68	3.40	1.48	9.56	*9.*	8.08	*8.*	6.71	10.64	*10.*	9.04
H 3	Buffalo Fert. Co.'s Extra Bone & Pot.	......	.....	......	......	......	6.12	4.66	0.70	11.48	*11.*	10.78	*10.*	8.44	6.95	*8.*	5.91
A 9	Buffalo Fert. Co.'s Farmer's Choice...	......	1.19	1.19	*0.82*	4.52	5.68	4.20	1.72	11.60	*9.*	9.88	*8.*	8.17	4.72	*5.*	4.01
D 11	Buffalo Fert. Co.'s Fish Guano.........	......	1.12	1.12	*0.82*	4.26	6.40	3.29	2.21	11.90	*10.*	9.69	*9.*	8.30	1.89	*2.*	1.61
H 2	Buffalo Fert. Co.'s General Crop........	......	......	......	......	......	4.36	5.26	0.88	10.50	......	9.62	*9.*	7.52	3.02	*3.*	2.57
A 11	Buffalo Fert. Co.'s Ideal Wheat & Corn	(i) 0.63	1.12	1.75	*1.64*	6.37	5.88	3.72	1.00	10.60	*10.*	9.60	*9.*	7.70	6.01	*5.*	5.11
F 11	Burl. Rend. Co.'s Animal Fertilizer...	......	2.81	2.81	*2.*	10.68	0.32	4.09	3.53	7.94	7.	4.41	*4.*	4.53	4.13	*4.*	3.51
F 10	Burl. Rend. Co.'s Special Potato......	......	2.67	2.67	*2.4*	10.15	0.04	3.61	4.23	7.88	*8.*	3.65	*5.*	4.25	6.62	*6.*	5.63
A 15	Coe-Mort. Co.'s Col. Corn & Potato...	§0.37	0.89	1 26	*1.23*	4.64	6.44	2.52	0.72	9.68	*9.5*	8.96	*8.5*	7.20	2.56	*2.5*	2.18
F 9	Coe-Mort. Co's Gold Brand Exc. Gua.	......	2.76	2.76	*2.47*	10.49	5.88	2.45	1.25	9.58	*9.*	8.33	*8.*	6.92	5.69	*6.*	4.84

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

(h) As nitrates, 0.19 percent; as ammonia salts, 0.76 percent.

(i) As nitrates, 0.28 percent; as ammonia salts, 0.35 percent.

ANALYSES OF LICENSED FERTILIZERS

Station	Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
											Total		Available					
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
A	14	Coe-Mort. Co's High Gd. Ammo. Bone	§0.21	1.96	2.17	*1.85*	$8.16	5.84	4.26	0.54	10.64	*9.*	10.10	*8.*	$7.86	3.22	*3.*	$2.74
D	13	Coe-Mort. Co's New Eng. Corn Fert...	§0.29	0.69	0.98	*0.8*	3.61	4.92	2.73	0.47	8.12	*8.5*	7.65	*7.5*	6.04	2.74	*3.*	2.33
D	14	Coe-Mort. Co'sNew Eng. Potato Fert...	§0.66	0.66	1.32	*0.8*	4.75	5.22	4.03	0.91	10.16	*8.5*	9.25	*7.5*	7.36	2.75	*3.*	2.34
H	1	Coe-Mort.Co's Prize Brand Grass&Gr.	......	......	......	......	......	8.32	3.86	0.60	12.78	*11.*	12.18	*10.*	9.60	1.49	*2.*	1.27
E	4	Essex Fert. Co.'s A 1 Superphosphate	......	1.70	1.70	*1.2*	6.46	5.84	1.84	1.32	9.00	*8.*	7.68	7.	6.49	2.76	*2.*	2.35
E	3	Essex Fert. Co.'s Corn, Grain, Grass..	0.88	2.25	3.13	*3.28*	11.45	4.12	1.96	1.26	7.34	7.	6.08	*6.*	5.17	11.91	*10.*	10.12
B	1	Essex Fert. Co.'s Potato, Root, Veg..	0.84	2.46	3.30	*3.25*	12.12	4.80	1.90	1.38	8.08	7.	6.70	*6.*	5.72	10.17	*10.*	8.64
E	1	Essex Fert. Co.'s Grass & Grain Fert.	......	1.13	1.13	*0.82*	4.29	5.72	2.55	2.17	10.44	*9.*	8.27	*8.*	7.24	4.51	*4.*	3.83
E	2	Essex Fert. Co.'s Market Gar. & Pot.	......	1.95	1.95	*2.*	7.41	7.06	1.02	1.08	9.16	*9.*	8.08	*8.*	6.79	5.48	*5.*	4.66
B	2	Essex Fert. Co.'s XXX Fish & Potash	......	2.21	2.21	*2.*	8.40	6.16	2.14	1.54	9.84	*9.*	8.30	*8.*	7.05	3.16	*3.*	2.69
H	6	Lister's Animal Bone & Potash No. 2	......	......	......	......	......	5.80	4.19	1.43	11.42	*11.*	9.99	*10.*	8.14	2.23	*2.*	1.90
C	12	Lister's G Brand........................	......	1.12	1.12	*0.82*	4.26	6.10	2.00	1.22	9.32	*10.*	8.10	*8.*	6.77	4.17	*4.*	3.54

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number		BRAND	Nitrogen					Phosphoric Acid								Potash		
											Total		Available					
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Found	Guar.	Found	Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
E	8	Lister's Grass & Oats Fertilizer.........	......	1.05	1.05	*0.82*	$3.99	6.08	2.19	1.53	9.80	......	8.27	*8.*	$7.00	4.90	*4.*	$4.17
E	9	Lister's Oneida Special	......	1.04	1.04	*0.82*	3.95	5.84	1.98	1.10	8.92	*8.*	7.82	*7.*	6.50	1.50	*1.*	1.28
C	13	Lister's Potato Manure...........	(k) 2.37	1.42	3.79	*3.3*	13.39	6.72	1.74	1.38	9.84	*9.*	8.46	*8.*	7.14	7.44	*7.*	6.32
B	6	Lister's Special Corn Fertilizer..........	§0.64	1.25	1.89	*1.65*	6.93	5.48	2.62	1.82	9.92	*9.*	8.10	*8.*	6.94	3.30	*3.*	2.81
E	10	Lister's Special Potato Fertilizer........	§0.30	1.58	1.88	*1.65*	7.02	4.48	3.27	3.01	10.76	*9.*	7.75	*8.*	7.07	3.78	*3.*	3.21
E	11	Lister's Special Ten Percent Potato...	§0.24	1.67	1.91	*1.65*	7.17	6.92	1.69	1.55	10.16	*9.*	8.61	*8.*	7.33	10.93	*10.*	9.29
B	5	Lister's Success Fertilizer	......	1.44	1.44	*1.24*	5.47	6.72	2.86	1.78	11.36	*11.*	9.58	*9.*	8.09	2.14	*2.*	1.82
B	7	Lowell (Swift's) Animal Brand....	......	2.74	2.74	*2.46*	10.41	6.88	1.74	1.06	9.68	*10.*	8.62	*8.*	7.14	4.42	*4.*	3.76
E	6	Lowell (Swift's) Bone Fert. Corn & Gr.	......	1.51	1.51	*1.64*	5.74	6.24	1.94	1.64	9.82	*9.*	8.18	*8.*	7.00	3.38	*3.*	2.87
E	7	Lowell (Swift's) Cereal Fertilizer......	......	1.00	1.00	*0.82*	3.80	5.44	2.17	1.11	8.72	*8.*	7.61	*7.*	6.31	1.44	*1.*	1.20
C	14	Lowell (Swift's) Empress Brand......	......	1.47	1.47	*1.23*	5.59	5.82	2.02	0.96	8.80	*8.*	7.84	*7.*	6.45	2.19	*2.*	1.86
B	8	Lowell (Swift's) Potato Manure........	......	1.89	1.89	*1.64*	7.18	5.20	2.28	1.04	8.52	*8.*	7.48	*7.*	6.17	4.12	*4.*	3.50

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.
(k) As nitrates, 0.67 percent; as ammonia salts, 1.70 percent.

ANALYSES OF LICENSED FERTILIZERS

Station Number		BRAND	Nitrogen					Phosphoric Acid								Potash		
			From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total Found	Total Guar.	Available Found	Available Guar.	Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
E	5	Lowell (Swift's) Potato Phosphate....	......	2.50	2.50	*2.46*	$9.50	6.24	2.02	1.44	9.70	*9.*	8.26	*8.*	$6.97	6.75	*6.*	$5.74
B	9	Lowell (Swift's) Sterling Phosphate...	......	1.12	1.12	*0.82*	4.26	5.48	2.96	1.84	10.28	*9.*	8.44	*8.*	7.19	4.10	*4.*	3.48
C	15	Lowell (Swift's) Superior Phosphate..	0.70	3.19	3.89	*3.69*	14.43	4.62	2.76	1.02	8.40	*8.*	7.38	*7.*	6.04	9.93	*10.*	8.44
E	12	N. E. Fert. Co.'s Corn & Grain Fert...	......	1.55	1.55	*1.23*	5.89	5.48	2.00	1.22	8.70	*8.*	7.48	*7.*	6.27	2.57	*2.*	2.18
F	1	N. E. Fert. Co.'s Corn Phosphate......	......	1.74	1.74	*1.64*	6.61	6.24	2.44	1.82	10.50	*9.*	8.68	*6.*	7.43	3.18	*3.*	2.70
B	10	N. E. Fert. Co.'s Peerless Fert...........	......	0.98	0.98	*0.82*	3.72	5.44	2.56	0.96	8.96	*8.*	8.00	*7.*	6.52	1.14	*1.*	0.97
B	11	N. E. Fert. Co.'s Potato Fertilizer......	......	1.86	1.86	*1.64*	7 07	4.32	2.67	1.45	8.44	*8.*	6.99	*7.*	5.91	4.27	*4.*	3.63
G	19	P. & P. Co.'s Aroostook Special.........	0.95	2.82	3.77	*3.68*	13.86	4.96	2.70	0.60	8.26	*8.*	7.66	*7.*	6.10	10.01	*10.*	8.51
G	10	P. & P. Co.'s Grain Grower Brand.....	......	1.49	1.49	*1.23*	5.66	4.74	2.21	1.11	8.06	*8.*	6.95	*7.*	5.78	2.10	*2.*	1.79
G	20	P. & P. Co.'s Maine State.	0.95	2.37	3.32	*3.28*	12.15	4.52	1.92	1.22	7.66	*7.*	6.44	*6.*	5 45	11.08	*10.*	9.42
F	15	P. & P. Co.'s Plymouth Rock Fert......	......	2.67	2.67	*2.47*	10.15	5.04	2.77	3.49	11.30	*9.*	7.81	*8.*	7.37	4.50	*4.*	3.83
G	11	P. & P. Co.'s Potato Fertilizer..........	0.55	2.28	2.83	*1.64*	10.48	4.52	2.67	1.13	8.32	*7.*	7.19	*6.*	5.94	6.04	*6.*	5.13

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

ANALYSES OF LICENSED FERTILIZERS

Station Number	BRAND	NITROGEN					PHOSPHORIC ACID								POTASH		
		From Nitrates	From Organic Matter	Total Found	Total Guaranteed	Valuation of Nitrogen‡	Soluble	Reverted	Insoluble	Total		Available		Valuation of Phosphoric Acid‡	Found	Guaranteed	Valuation of Potash‡
										Found	Guar.	Found	Guar.				
F 16	P. & P. Co.'s Potato Grower..............	......	2.57	2.57	*2.46*	$9.77	4.36	2.06	1.54	7.96	*7.*	6.42	*6.*	$5.55	10.93	*10.*	$9.29
G 18	P. & P. Co.'s Special Potato	0.86	2.56	3.42	*3.28*	12.57	5.92	2.58	1.64	10.14	*9.*	8.50	*8.*	7.21	7.64	7.	6.49
G 9	P. & P. Co.'s Star Brand Superphos...	.....	1.70	1.70	*1.64*	6.46	1.64	5.21	1.23	8.08	*8.*	6.85	7.	5.45	4.30	*4.*	3.66
C 8	R. & H. Co.'s Complete Phosphate.....	0.28	1.26	1.54	*1.5*	5.71	4.36	3.36	0.92	8.64	*8.*	7.72	7.	6.21	6.10	*5.*	5.19
F 3	R. & H. Co.'s Grass & Grain Fert......	(l) 0.50	2.80	3.30	*2.2*	12.32	0.04	8.02	7.58	15.64	*16.*	8.06	*6.6*	8.67	11.10	*12.*	9.44
¶C 9	R. & H. Co.'s New Market Garden....	0.63	0.98	1.61	*2.*	5.80	3.42	2.74	0.72	6.88	7.	6.16	*6.*	4.92	10.97	*10.*	9.32
F 4	R. & H. Co.'s Oats and Top Dressing.	7.74	1.21	8.95	*8.5*	30.14	0.08	4.28	5.48	9.84	*8.*	4.36	*3.9*	5.26	9.31	*8.*	7.91
B 17	R. & H. Co.'s Potato Phosphate........	0.88	1.15	2.03	*2.*	7.27	6.84	3.50	0.98	11.32	*10.*	10.34	*9.*	8.31	5.77	*5.*	4.90
B 18	R. & H. Co.'s Sol. Corn & Gen. Crops	0.81	1.93	2.74	*2.5*	10.00	2.60	4.52	2.48	9.60	*8.*	7.12	*5.5*	6.23	8.94	*8.*	7.60
*F 2	R. & H. Co.'s Sol. Potato Manure......	(m) 2.51	2.91	5.42	*5.*	19.37	0.40	7.28	6.18	13.86	*10.*	7.68	7.	7.89	*5.60	*5.*	5.39
*G 8 *J12	R. & H. Co.'s Sol. Tobacco Manure...	(n) 2.35	2.56	4.91	*5.*	17.52	1.12	5.06	5.15	11.33	*10.*	6.18	7.	6.50	*13.91	*10.*	13.73

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 128. §As ammonia salts.

(l) As nitrates, 0.25 per cent; as ammonia salts, 0.25 percent.

(m) As nitrates, 2.21 percent; as ammonia salts, 0.30 percent.

(n) As nitrates, 2.05 percent; as ammonia salts, 0.30 percent.

¶A second sample from another location exceeds nitrogen guaranty by over 0.50 percent.

VI. ANALYSES OF FERTILIZERS FOR FIVE YEARS, 1905-1909

The buyer of mixed goods usually makes his choice before the analyses are published. The Station prints the analyses of about 60 brands early in April, and puts out its final bulletin in June. These dates are far in advance of the issuance of similar figures by other northern stations, yet the information they convey often reaches the buyer too late to be of service; and if station analyses are consulted at all, those of former years are used. These may or may not be safe guides. If, however, reference to analyses for successive years shows essential uniformity of composition in the past *and an unchanged guaranty,* the buyer is safe in assuming that the former figures will be applicable. If the guaranty statement has been changed, and if former statements have been lived up to in the past years, the presumption is in favor of similar keeping of promises for the present year.

In order to facilitate such reference and to indicate something of the evenness or variation in composition from year to year of the several brands, tables are given herewith showing the nitrogen, available phosphoric acid and potash percentages for the past five years of the 135 of the 136 licensed brands.[1] The guaranties printed in the tables are those for 1909 as well as for 1905-1908 with a few exceptions, which are foot-noted. The * indicates that sulphate of potash was used as a source of potash. the †, that 0.20 percent or more of nitrogen was present in water-soluble shapes (as nitrate of soda or as sulphate of ammonia).

These tables, containing the essentials of five years' inspection, ought to prove helpful in choosing fertilizers, particularly when they are bought early in the season.

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[1] One brand newly licensed this year not found on sale.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
American Agricultural Chem. Co.'s	Grass and Lawn Top Dres.	†5.19	†4.98	†3.82	†5.40	†4.23	*3.91*	5.23	6.18	5.50	6.90	5.94	*5.*	*3.02	3.12	2.85	*4.49	3.14	*2.*
	Grass and Oats Fertilizer.	......	......	......	......	......	......	......	......	......	......	12.13	*11.*	......	......	......	......	1.95	*2.*
	High Grade Ten Percent...	†2.67	†2.81	†2.74	†2.37	†3.30	*2.4*	6.68	6.14	6.32	6.00	6.84	*6.*	10.40	10.80	10.75	9.88	10.09	*10.*
	No. West Chal. Crop Prod	......	......	......	......	1.18	*1.03*	......	......	......	......	9.99	*8.*	......	......	......	......	2.36	*2.*
	Baker's Complete Potato ...	†3.61	†3.47	†3.37	†3.44	†3.40	*3.3*	6.71	6.68	7.34	6.36	6.86	*6.*	10.04	9.12	10.48	9.87	10.18	*10.*
	Baker's Harvest Home......	1.51	1.30	1.30	1.12	1.26	*1.03*	7.94	9.32	8.04	8.08	9.28	*8.*	2.10	2.41	2.00	2.00	2.24	*2.*
	Baker's Standard UnXLD..	†2.50	†2.39	†1.82	†1.51	1.75	*1.65*	7.72	8.14	9.04	8.04	9.60	*8.*	2.26	2.68	2.04	2.24	2.35	*2.*
	Bradley's Alkaline Bone....	......	......	......	......	......	......	10.69	11.26	11.30	10.32	11.57	*11.*	2.17	2.24	2.36	1.91	2.20	*2.*
	Bradley's Comp.Pot.& Veg.	†3.86	†3.33	†4.00	†3.49	†3.30	*3.3*	7.82	8.92	8.20	8.68	7.64	*8.*	6.80	*7.58	7.88	6.73	6.90	*7.*
	Bradley's Comp. 10 Perc't..	†3.61	†3.40	†3.58	†3.47	†3.26	*3.3*	6.78	6.66	6.66	6.78	7.50	*6.*	10.30	10.64	11.24	10.25	9.99	*10.*
	Bradley's Corn Phosphate..	†2.32	†2.21	†2.14	†2.17	†2.60	*2.06*	8.01	8.68	8.52	8.36	9.39	*8.*	2.09	2.00	1.84	1.90	2.17	*1.5*
	Bradley's Eclipse Phos......	1.40	1.23	1.33	†0.90	1.31	*1.03*	7.68	8.58	7.99	9.30	9.58	*8.*	2.36	2.32	2.04	2.12	2.48	*2.*
	Bradley's Niagara Phos......	1.19	1.40	1.23	1.12	1.12	*0.82*	6.77	7.50	7.66	7.98	8.01	*7.*	1.60	1.60	1.31	1.45	1.68	*1.*
	Bradley's Potato Fertilizer	†2.32	†2.24	†2.10	†1 98	†2.17	*2.06*	8.14	8.42	8.14	8.30	9.42	*8.*	3.08	3.48	3 36	3.36	2.97	*3.*
	Bradley's Potato Manure...	†2.77	†2.74	†2.63	†2.83	†2.91	*2.5*	7.58	6.74	7.94	6.88	6.08	*6.*	5.95	5.44	5.40	6.78	4.98	*5.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
American Agricultural Chemical Co.'s	Bradley's Vermonter.........	†2.24	†2.17	†2.32	†2.21	†2.42	*2.06*	7.52	8.20	8.38	8.18	8.34	*8.*	3.24	3.20	3.35	3.11	3.09	*3.*
	Bradley's XL Superphos...	†2.67	†2.53	†2.70	†2.95	†2.46	*2.5*	9.48	9.28	9.00	9.08	9.24	*9.*	2.27	2.44	2.33	2.71	2.28	*2.*
	Clark's Cove Bay State G.G.	†2.28	†2.17	2.53	†2.14	2.32	*2.06*	9.23	8.42	9.23	8.38	7.98	*8.*	1.84	2.08	1.98	1.65	1.88	*1.5*
	Clark's Cove King Philip...	1.23	1.33	1.33	1.26	1.26	*1.03*	8.09	8.94	8.06	8.38	8.34	*8.*	2.27	2.47	2.16	2.06	2.22	*2.*
	Clark's Cove Potato Fert...	†2.21	†2.42	†2.39	†2.10	2.39	*2.06*	8.05	8.84	8.78	8.56	8.10	*8.*	3.34	3.54	3.18	3.50	3.27	*3.*
	Cleveland Fertilizer..........	1.33	1.33	1.23	1.37	1.14	*1.03*	8.54	8.44	8.38	8.78	9.30	*8.*	2.67	2.36	2.03	2.20	2.24	*2.*
	Cleveland Potato Phos......	†2.07	†2.14	†2.10	†2.14	†2.24	*2.06*	8.02	8.66	8.18	8.26	9.16	*8.*	3.00	3.12	3.85	3.21	3.47	*3.*
	Cleveland Superphosphate.	†2.17	†2.14	†2.10	†2.17	†2.24	*2.06*	8.49	9.02	8.06	8.08	8.66	*8.*	1.81	1.99	1.80	1.92	2.12	*1.5*
	Crocker's Am. Corn Phos...	†2.39	†2.21	†2.07	†2.01	†2.35	*2.06*	9.60	8.66	8.02	8.14	9.10	*8.*	1.86	2.01	1.92	2.25	1.90	*1.5*
	Crocker's N. Rival Am. Bo.	1.30	1.37	1.16	1.16	†1.16	*1.03*	7.86	8.54	8.04	8.82	9.34	*8.*	2.14	2.44	1.95	2.05	2.21	*2.*
	Crocker's Pot., Hop & Tob.	†2.49	†2.12	†2.10	†2.05	†2.28	*2.06*	7.78	8.54	7.87	7.68	9.09	*8.*	3.94	3.12	3.78	3.22	3.19	*3.*
	Crocker's Potato Special....	†3.68	†3.33	†3.30	†3.33	†3.75	*3.3*	6.78	6.90	7.32	6.08	7.58	*6.*	10.07	10.45	9.84	10.44	9.84	*10.*
	Cumberland Guano..........	1.37	1.33	....	....	†1.37	*1.03*	8.32	8.72	......	....	8.70	*8.*	2.22	2.28	....	....	1.93	*2.*
	Cumberland Potato Fert....	†2.39	†2.24	†2.17	†1.95	†2.24	*2.06*	8.13	8.72	7.74	8.66	9.24	*8.*	3.21	3.49	3.10	3.78	3.36	*3.*
	Cumberland Superphos.....	†2.07	†2.10	†2.24	†2.14	†2.32	*2.06*	8.05	8.36	8.00	7.98	8.68	*8.*	1.94	2.03	1.87	1.82	2.32	*1.5*

*Potash in brands thus marked is largely if not entirely sulphate, †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

	Brand	Nitrogen						Available Phospho'c Acid						Potash					
		1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
American Agricultural Chemical Co.'s	Darling's Farm Favorite....	†2.28	†2.12	†2.21	†2.05	†2.24	*2.06*	7.64	8.88	8.12	7.96	8.66	8.	3.20	3.38	3.32	3.01	3.17	*3.*
	Darling's General Fert......	......	......	......	......	†1.68	*0.82*	......	......	......	......	7.58	*8.*	......	......	......	......	4.18	*4.*
	Great East. Garden Special	†3.54	†3.65	†3.30	†3.65	†3.56	*3.3*	8.93	7.79	8.00	8.18	7.12	*8.*	7.18	7.72	7.10	7.26	7.63	7.
	Great East. General Fert...	0.95	1.09	1.09	1.44	1.18	*0.82*	7.80	8.06	8.08	7.70	7.99	*8.*	4.04	4.70	4.03	5.09	4.05	*4.*
	Great East. No. Corn Spec.	†2.24	†2.14	†2.60	†2.21	†2.28	*2.06*	8.02	8.42	8.60	8.40	8.47	*8.*	2.01	2.23	1.72	1.89	1.75	*1.5*
	Great East. Potato Manure	†2.24	†2.14	†2.24	†2.17	†2.17	*2.06*	8.05	8.78	8.18	8.20	8.61	*8.*	3.42	3.32	3.44	3.20	3.04	*3.*
	Pac. Gu. Co.'s Nobsque Gu.	1.09	1.40	1.30	1.37	1.11	*1.03*	7.70	8.32	8.15	8.74	9.56	*8.*	3.26	2.32	2.02	2.02	2.02	*2.*
	Pac. Gu. Co.'s Potato Spec.	†2.42	†2.24	†2.39	†2.07	†2.24	*2.06*	8.60	9.00	8.08	8.28	8.14	*8.*	3.34	3.40	3.02	3.22	3.34	*3.*
	Pac. Gu. Co.'s Sol. Pac. Gu.	†2.24	†2.21	†2.56	†2.14	†2.10	*2.06*	7.79	8.24	8.02	8.70	8.00	*8.*	2.05	2.14	1.62	1.98	1.77	*1.5*
	Quinnipiac Climax Phos....	1.40	1.40	1.26	1.37	1.35	*1.03*	7.95	8.26	7.84	8.84	8.38	*8.*	2.68	2.26	1.94	1.99	2.36	*2.*
	Quinnipiac Corn Manure...	†2.39	†2.28	†2.24	†2.05	†2.17	*2.06*	7.90	8.84	8.16	8.18	9.03	*8.*	1.70	2.19	1.80	2.08	2.18	*1.5*
	Quinnipiac Market Garden	†3.44	†3.58	†4.07	†3.40	†3.39	*3.3*	8.68	7.92	7.99	8.03	8.26	*8.*	7.21	8.18	7.84	6.96	7.72	7.
	Quinnipiac Potato Phos.....	†2.35	†2.21	†2.21	†2.07	†2.24	*2.06*	8.60	8.86	8.30	8.50	9.09	*8.*	3.56	3.51	3.12	3.28	3.08	*3.*
	Read's Farmers' Friend.....	†2.49	†2.17	†2.24	†1.81	†2.28	*2.06*	8.26	8.96	8.26	8.30	8.78	*8.*	4.21	3.40	3.30	3.62	3.18	*3.*
	Read's H. G. F.'s Friend...	†3.51	†3.68	†3.72	†3.12	†3.32	*3.3*	6.40	6.94	6.56	6.30	6.85	*6.*	10.52	11.42	11.27	10.47	10.06	*10.*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
Am. Agricultural Chemical Co.'s	Read's Leader Bl. and Bone	1.19	1.26	1.16	1.19	†1.12	*0.82*	6.49	8.12	7.02	8.28	7.38	*7.*	1.58	1.34	1.39	1.32	1.02	*1.*
	Read's Prac. Potato Spec'l	0.98	1.16	1.26	1.51	1.04	*0.82*	6.46	7.68	6.99	7.24	7.44	*4.*	7.86	8.64	8.08	10.03	8.08	*8.*
	Read's Standard Superphos.	0.95	1.19	1.09	1.47	1.16	*0.82*	8.27	8.44	8.08	7.67	8.20	*8.*	4.00	4.06	4.09	5.07	4.09	*4.*
	Read's Sure Catch Fert......	......	......	......	......	......	......	10.94	10.74	10.88	10.06	11.99	*10.*	2.32	2.18	2.22	1.57	2.10	*2.*
	Tucker's Imperial all Crops	1.26	1.33	1.33	1.07	1.30	*1.03*	8.54	8.32	8.50	9.66	9.19	*8.*	2.26	2.52	2.30	2.22	2.59	*2.*
	Tucker's Imperial Corn......	1.05	1.33	1.26	0.88	1.33	*1.03*	7.40	8.28	8.16	9.56	8.64	*8.*	2.20	2.57	2.14	2.17	2.04	*2.*
	Tucker's Imperial Potato...	1.33	1.44	1.23	1.12	1.47	*1.03*	8.31	8.34	8.02	9.70	8.54	*8.*	2.16	2.68	2.09	2.31	2.30	*2.*
	W. & Cl. Am. Corn Phos...	†2.21	†2.17	†2.60	†1.96	†2.14	*2.06*	8.72	8.58	8.56	8.48	8.85	*8.*	1.85	1.73	2.04	1.79	2.09	*1.5*
	W. & Cl. Am. High Gr. Sp.	†3.72	†3.58	†3.40	†3.44	†3.35	*3.3*	8.70	8.11	8.28	8.01	8.12	*8.*	*7.75	7.18	7.03	7.26	6.77	*7.*
	W. & Cl. Am. Potato Man.	†2.32	†2.14	†2.32	†2.10	†2.28	*2.06*	7.95	9.18	8.08	8.16	9.16	*8.*	3.36	3.40	3.79	3.15	3.38	*3.*
	W. & Cl. Am. Potato Phos.	†2.70	†2.53	†2.95	†2.74	2.79	*2.5*	8.02	6.18	7.40	7.28	6.37	*6.*	6.90	5.40	6.86	5.60	4.84	*5.*
	W. & Cl. Prolific Crop Pro.	1.51	1.26	1.12	1.37	1.19	*0.82*	7.46	6.12	8.20	8.14	7.50	*7.*	2.47	1.42	2.00	1.25	1.67	*1.*
	W. & Cl. Royal Bone Phos.	†1.16	1.33	1.26	1.33	1.26	*1.03*	7.80	8.90	8.42	8.80	9.09	*8.*	2.25	2.25	2.00	1.95	2.03	*2.*
	Armour's Complete Man....	......	......	......	......	†3.21	*3.3*	......	......	......	......	6.52	*6.*	......	......	......	......	10.14	*10.*
	Armour's Corn Special......	......	......	......	......	1.28	*1.65*	......	......	......	......	8.74	*8.*	......	......	......	......	5.16	*5.*

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*Potash in brands thus marked is largely if not entirely sulphate, †Contained 0.20 per cent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
Armour's High Gd. Potato.	......	......	......	......	1.86	*1.65*	......	......	......	......	9.84	*8*	......	......	......	......	10.35	*10.*
Armour's Oats and Clover..	......	......	......	......	......	......	......	......	......	.. ....	11.80	*10.*	..... .	......	......	......	8.88	*8.*
Bowker's Corn Phosphate..	†1.79	†2.17	†2.00	†1.61	†1.79	*1.65*	8.36	8.42	8.60	8.54	8.10	*8.*	2.15	2.58	2.32	2.15	2.29	*2.*
Bowker's Hill and Drill....	†2.63	†2.77	†2.60	†2.86	†2.74	*2.47*	9.63	9.31	9.26	9.44	9.90	*9.*	2.15	2.56	2.17	2.68	2.04	*2.*
Bowker's Market Garden...	†2.56	†3.02	†2.60	†2.77	†2.49	*2.47*	6.10	6.12	6.48	6.66	5.74	*6.*	10.90	10.79	10.04	9.85	11.19	*10.*
Bowker's Potash Bone......	1.05	1.40	1.12	1.12	1.14	*0.82*	6.08	8.76	8.10	8.76	9.08	*6*	2.41	2.12	2.12	1.93	2.26	*2.*
Bowker's Potash or Staple.	†1.05	1.23	1.19	†1.30	1.25	*0.83*	7.54	8.58	7.62	8.98	9.20	*8.*	2.93	3.54	3.24	3.58	4.80	*3.*
Bowker's Pot. and Veg. F.	†2.49	†2.56	†2.81	†2.32	2.67	*2.47*	8.17	9.06	9.44	8.42	9.22	*8.*	4.43	4.40	4.72	4.57	3.84	*4.*
Bowker's Pot. and Veg. P.	1.82	†2.17	†1.89	†1.65	†1.79	*1.65*	(a) 8.22	(a) 8.31	8.82	8.70	8.03	*8.*	2.11	2.48	2.31	2.19	2.24	*2.*
Bowker's Square Brand....	†2.10	†2.14	†1.96	†2.09	†1.98	*1.65*	5.77	8.56	6.72	8.22	7.85	*6.*	2.48	2.55	2.64	2.33	1.96	*2.*
Bowker's Stkbdg. Corn M.	†3.30	†3.79	†3.51	†3.55	†3.68	*3.29*	10.28	9.26	9.02	8.28	8.75	*10.*	7.27	7.58	7.60	7.01	7.04	*7.*
Bowker's Stkbdg. Pot. M.	3.47	†3.54	†3.33	†3.24	†3.40	*3.29*	6.68	5.98	6.60	6.14	6.90	*6.*	10.06	9.94	10.10	10.27	9.98	*10.*
Bowker's Stkbdg. Top Dr.	†......	......	†6.03	†4.91	†4.77	*4.93*	......	......	6.06	4.44	7.77	*4.*	......	......	6.51	7.85	6.60	*6.*
Bowker's Super with P't'sh	......	......	......	......	......	......	......	......	11.40	9.93	11.34	*10.*	......	.... .	2.52	1.50	1.80	*1.*
Bowker's Sure Crop Phos..	†0.95	1.54	1.09	1.16	1.08	*0.82*	(a) 8.03	(a) 7.72	8.23	9.06	8.44	*8.*	2.00	2.50	1.95	2.02	2.37	*2.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(a) Available phosphoric acid guaranty, 9 percent.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
Bowker's Vt. Grange Ch..	†2.28	†2.17	......	†2.17	†2.32	*2.06*	9.16	8.84	......	8.02	8.30	*8.*	3.30	3.02	......	3.05	3.24	*3.*
Buff. F. Co. Celery & Pot..	......	......	......	†1.68	†1.65	*1.64*	......	......	......	7.71	8.08	*8.*	......	......	......	10.45	10.64	*10.*
Buff. F. Co. Ex. Bone & Pot.	......	......	......	......	......	......	......	......	......	......	10.78	*10.*	......	......	......	......	6.95	*8.*
Buff. F. Co. Farm. Choice..	0.84	0.98	0.98	†1.09	1.19	*0.82*	8.38	8.13	6.28	8.48	9.88	*8.*	*5.98	*4.40	4.14	5.02	4.72	*5.*
Buff. F. Co. Fish Guano....	0.88	1.05	1.43	†1.26	1.12	*0.82*	9.87	9.14	6.76	9.28	9.69	*9.*	*1.86	*2.54	3.14	3.25	1.89	*2.*
Buff. F. Co. General Crop..	......	......	......	......	......	......	10.35	8.90	9.20	10.77	9.62	*9.*	*1.68	*2 35	3.65	5.15	3.02	*3.*
Buff. F. Co. High Gr'd Man	3.10	†2.71	......	......	......	*3.28*	8.56	7.18	......	......	......	*7.*	*8.24	*8.66	.....	......	......	*10.*
Buff. F. Co. Id. Wht. & Co.	1.44	1.68	1.51	1.93	†1.75	*1.64*	10.96	8.71	7.60	8.52	9.60	*9.*	*4.31	*5.00	5.06	4.59	6.01	*5.*
Burl. R. Co. Animal Brand	2.78	2.74	2.80	2.95	2.81	*2.*	(b) 4.81	(b) 4.66	(b) 6.44	5.32	4.41	*5.*	4.91	3.82	4.10	4.50	4.13	*5.*
Burl. R. Co. Spec. Potato..	......	......	2.91	2.95	2.67	*2.47*	......	......	6 76	5.06	3.65	*5.*	......	......	5.42	7.34	6.62	*6.*
Coe-Mort. Corn and Potato.	1.66	1.46	......	1.26	†1.26	*1.23*	8.95	8.70	......	8.06	8.96	*8 5*	*3.03	*2.57	......	2.43	2.56	*2 5*
Coe-Mort. Gold Brand.......	†2.17	†2.56	†2.00	†2.42	2.76	*2.4*	8.99	8.76	5.52	8.05	8.33	*8.*	*4.64	*6.06	9.40	5.67	5.69	*6.*
Coe-Mort. H. G. A. B. Super	†2.46	†2.14	......	2.03	†2.17	*1.85*	(c) 9.67	(c) 9.00	.....	(c) 9.74	10.10	*8.*	*(c) 2.90	*(c) 2.40	......	(c) 2.84	3.22	*3.*
Coe-Mort. New Eng. Corn...	1.33	1.05	0.91	†1.40	0.98	*0.8*	9.67	8.68	5.73	9.36	7.65	*7.5*	*3.18	*3.01	*3.23	3.05	2.74	*3.*
Coe-Mort. New Eng. Potato	1.44	1.02	0.95	0.98	1.32	*0.8*	9.07	8.51	5.70	8.28	9.25	*7.5*	*3.52	*3.31	*3.49	2.62	2.75	*3.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(b) Available phosphoric acid guaranty, 4 percent.

(c) Available phosphoric acid guaranty, 9 percent; potash guaranty, 2.25 percent.

ANALYSES OF LICENSED FERTILIZERS—1905-1908

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
Coe's Prize Br. Grass & Gr.	......	......	......	......	......	.....	9.53	11.50	......	11.18	12.18	*10.*	2.18	*2.03	......	1.64	1.49	*2.*
Essex A 1 Superphos.........	......	......	.....	1.14	1.70	*1.2*	......	......	......	8.42	7.68	7.	......	......	......	2.13	2.76	*2.*
Essex Comp. Corn, etc......	......	.....	......	†3.13	3.13	*3.28*	......	......	......	6.10	6.08	*6.*	......	......	......	10.44	11.91	*10.*
Essex Comp. Potatoes, etc..	......	......	......	†3.44	†3.30	*3.25*	......	......	......	5.58	6.70	7.	......	......	......	10.80	10.17	*10.*
Essex Grass and Grain......	......	......	......	1.02	1.13	*0.82*	......	......	......	9.08	8.27	*8.*	.....	......	......	4.46	4.51	*4.*
Essex Mar. Garden & Pot..	......	......	......	1.98	1.95	*2.*	......	......	......	7.93	8.08	*8.*	......	......	......	5.55	5.48	*5.*
Essex XXX Fish & Pot....	......	......	......	2.10	2.21	*2.*	......	......	......	9.14	8.30	*8.*	......	......	......	3.04	3 16	*3.*
Lister's A. B. & Pot. No. 2	......	......	......	......	......	......	11.01	10.84	9.76	10.14	9.99	*10.*	2.25	2.21	2.01	2.17	2.23	*2.*
Lister's G. Brand.............	0.95	1.19	0.88	0.98	1.12	*0.82*	9.56	8.70	8.64	8.16	8.10	*8.*	3.73	4.02	4.03	3.94	4.17	*4.*
Lister's Grass and Oats......	......	1.05	......	0.95	1.05	*0.82*	......	8.18	......	8.05	8.27	*8.*	......	4.16	......	3.70	4.90	*4.*
Lister's Oneida Special......	0.95	0.91	0.98	0.98	1.04	*0.83*	7.11	7.04	7.70	7.34	7.82	7.	1.37	1.24	1.17	1.33	1.50	*1.*
Lister's Potato Manure......	†3.61	†3.51	†3.68	†3.61	†3.79	*3.3*	8.74	8.48	9.28	8.75	8.46	*8.*	7.94	7.07	7.00	7.26	7.44	7.
Lister's Special Corn Fert..	2.00	†1.75	1.82	1.79	†1.89	*1.65*	8.78	8.62	8.42	8.55	8.10	*8.*	3.34	3.46	3.30	3.49	3.30	*3.*
Lister's Special Pot. Fert...	2.00	†1.75	1.79	1.89	1.88	*1 65*	8 36	8.66	8.12	9.07	7.75	*8.*	3.23	3.13	3.18	3.35	3.78	*3.*
Lister's Special 10% Potato	1.86	†2.00	1.72	1.79	1.91	*1.65*	8.79	9.34	8.46	9.80	8.61	*8.*	11.62	10.01	7.97	10.41	10.93	*10.*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
Lister's Success Fertilizer..	1.40	1.40	1.40	1.30	1.44	*1.24*	9.38	10.02	9.08	9.42	9.58	*9.*	2.19	2.20	2.50	2.24	2.14	*2.*
Lowell (Swift's) Animal...	2.60	2.53	2.42	2.46	2.74	*2.47*	(d) 9.73	10.06	8.28	8.32	8.62	*8.*	4.06	4.18	4.35	4.15	4.42	*4.*
Lowell (Swift's) Bone Ft.	1.68	1.93	2.00	1.72	1.51	*1.64*	9.16	9.30	7.77	8.44	8.18	*8.*	3.43	3.24	3.24	3.26	3.38	*3.*
Lowell (Swift's) Cereal.. ...	1.09	0.95	1.16	1.02	1.00	*0.83*	7.72	6.52	7.84	7.32	7.61	7.	1.40	1.16	1.64	1.57	1.44	*1.*
Lowell (Swift's) Empress..	1.26	1.44	1.30	1.37	1.47	*1.23*	7.26	7.62	7.54	7.34	7.84	7.	2.50	2.09	2.01	2.23	2.19	*2.*
Lowell (Swift's) Pot. Man.	2.03	1.75	1.79	1.74	1.89	*1.64*	8.75	8.12	7.38	7.78	7.48	7.	*3.94	4.34	3.02	4.08	4.12	*4.*
Lowell (Swift's) Pot. Phos.	2.84	2.49	2.24	2.70	2.50	*2.46*	9.16	8.20	8.79	7.66	8.26	*8.*	*6.00	6.28	*5.30	5.67	6.75	*6.*
Lowell (Swift's) Sterling...	0.98	0.98	0.84	1.02	1.12	*0.82*	8.23	8.66	7.84	8.21	8.44	*8.*	3.65	3.62	4.28	4.06	4.10	*4.*
Lowell (Swift's) Superior..	......	†3.96	†3.79	†3.86	†3.89	*3.7*	......	8.76	7.40	7.60	7.38	7.	......	9.75	9.75	9.78	9.93	*10.*
N. E. F. Co., Corn & Grain	1.53	1.23	1.40	1.23	1.55	*1.23*	7.84	7.58	7.52	7.06	7.48	7.	2.45	2.20	1.88	2.06	2.57	*2.*
N. E. F. Co., Corn Phos......	1.86	1.89	1.82	1.84	1.74	*1.64*	7.98	9.62	7.76	8.00	8.68	*8.*	3.00	3.25	3.00	3.22	3.18	*3.*
N.E.F. Co., H.G. 10% Pot.	......	......	†3.79	3.81	......	*3.5*	......	......	7.00	7.04	......	7.	......	......	10.18	9.95	......	*10.*
N. E. F. Co., Peerless........	....	......	......	0.98	0.98	*0.82*	......	......	......	6.89	8.00	7.	......	......	......	1.23	1.14	*1.*
N. E. F. Co., Potato Fert..	1.86	1.86	1.75	1.89	1.86	*1.64*	7.85	8.14	7.28	7.12	6.99	7.	*4.13	*4.13	*3.47	4.06	4.27	*4.*
P. & P. Co.'s Aroostook.....	†......	†......	†3.86	†3.68	†3.77	*3.68*	......	......	7.20	7.48	7.66	7.	......	......	10.21	9.74	10.01	*10.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble notrogen, usually as nitrate of soda.

(d) Available phosphoric acid guaranty, 9 percent.

ANALYSES OF LICENSED FERTILIZERS—1905-1909

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar	1905	1906	1907	1908	1909	Guar
P. & P. Co.'s Grain Grower	......	1.12	1.33	1.47	1.49	*1.23*	......	8.02	6.66	7.32	6.95	*7.*	......	2.02	1.92	2.36	2.10	*2.*
P. & P. Co.'s Maine State..	......	......	......	......	† 3.32	*3.28*	......	......	6.20	......	6.44	*6.*	......	......	10.56	......	11.08	*10.*
P. & P. Co.'s Plym'h Rock	2.63	2.49	2.62	2.49	2.67	*2.47*	8.11	8.34	7.75	8.20	7.62	*8.*	4.08	4.11	3.86	4.32	4.50	*4.*
P. & P. Co.'s Potato Fert...	......	1.72	1.86	1.89	† 2.83	*1.65*	......	6.96	6.30	6.04	7.19	*6.*	......	6.87	7.44	4.16	6.04	*6.*
P. & P. Co.'s Pot. Grower..	......	......	......	† 2.49	2.57	*3.28*	......	......	......	6.26	6.42	*6.*	......	......	......	9.69	10.93	*10.*
P. & P. Co.'s Spec. Potato	† 3.33	† 3.30	† 3.30	† 3.18	† 3.42	*3.29*	8.36	8.60	8.14	9.94	8.50	*8.*	7.34	7.28	7.56	7.15	7.64	*7.*
P. & P. Co.'s Star Brand...	1.64	1.75	1.65	2 24	1.70	*1.65*	6.91	7.02	7.28	7.16	6.85	*7.*	(e) 2.50	(e) 2.78	3.98	4.15	4.30	*4.*
R. & H. Co.'s Compl. Pho	† (f) 1.12	† (f) 1.47	† (f) 1.16	† (f) 1.12	† 1.54	*1.5*	(f) 9.61	(f) 8.86	(f) 8.04	(f) 8.42	7.72	*7.*	(f) 4.17	(f) 4.72	(f) 4.66	(f) 4.03	6.10	*5.*
R. & H. Co.'s Grass & Gr...	† 2.46	2.81	3.33	3.05	3.80	*2.2*	8.39	8.06	6.03	7.12	8.06	*6.6*	12.00	12.66	14.43	10.83	11.10	*12.*
R.&H.Co.'s New Mkt. Gd.	......	......	......	......	† 1.61	*2.*	......	......	......	......	6.16	*6.*	......	....	......	......	10.97	*10.*
R. & H.Co.'s Oats & Top Dr.	† 8.65	† 8.54	† 8.21	† 8.70	† 8.95	*8.5*	(g) 4.69	(g) 5.48	(g) 4.25	(g) 4.83	4.36	*4.5*	10.00	8.02	9.80	10.29	9.31	*8.*
R. & H. Co.'s Potato Phos.	† 2.07	† 2.12	† 2.35	† 2.24	† 2.03	*2.*	9.79	8.40	9.82	8.82	10.34	*9.*	5.41	5.54	6.29	6.10	5.77	*5.*
R. & H. Co.'s Sol.Co.G'l Cp	† 3.12	† 2.70	† 2.35	† 2.35	† 2.74	*2.5*	(h) 6.79	(h) 6.14	(h) 7.84	(h) 6.40	7.12	*5.5*	8.40	9.25	8.85	9.14	8.94	*8.*
R. & H. Co.'s Sol. Potato...	† 5.57	† 4.35	† 4.53	† 4.95	† 5.42	*5*	7.97	7.36	7.95	8.48	7.68	*7.*	* 5.86	* 7.38	* 6.93	* 6.50	* 5.60	*5.*
R. & H. Co.'s Sol. Tobacco	......	† 5.75	† 5.30	† 4.55	† 4.91	*5.*	......	8.88	9.82	8.04	6.18	*7.*	......	* 9.61	* 10.92	* 14.46	* 13.91	*10.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of water soluble nitrogen, usually as nitrate of soda.

(e) Potash guaranty 2.5 percent. (f) Nitrogen guaranty, 1 percent; available phosphoric acid guaranty, 8 percent; potash guaranty, 3.5 percent. (g) Available phosphoric acid guaranty, 3.9 percent. (h) Available phosphoric acid guaranty, 6 percent.

VII. THE SERVICE OF A FERTILIZER CONTROL

The fertilizer bulletins put out by eastern stations are quite commonly found to be in larger demand than are those which treat of other matters. This fact indicates that they are helpful, and that they are appreciated and, to some extent at any rate, understood. It is unfortunate that these publications are more largely called for than are bulletins which deal with matters which are really of more importance. Yet the fact cannot be gainsaid. Notwithstanding their popularity, however, divers incorrect notions and inadequate conceptions are held touching this branch of station work. Hence, it seems worth while this year to state somewhat more in detail than has been hitherto done the nature, scope and service of fertilizer control work, in continuation as it were of the publication made in last year's issue wherein was set forth its history for twenty-five years in Vermont. This bulletin (No. 135) described the situation as it existed in the early days of small things, when fraud was common, as well as its present status when 20,000 tons are used yearly and the trade is to a considerable degree standardized. The changes in trade values, in composition, in selling price, in commercial values, etc. taking place during the various years of this quarter century were reviewed at length. It now seems worth while to go into some detail as to the method of the conduct of a modern fertilizer control and to set forth the benefits which those fully informed concerning its work may derive therefrom.

THE DIRECTION AND FINANCING OF A CONTROL

The conduct of this line of work in the several states is commonly lodged in the hands either solely or jointly of the Commissioner (or Board) of Agriculture and the Experiment station. Local considerations have usually determined its assignment to one or the other of these public agencies. The analytical work is quite commonly carried out at the station in the North Atlantic states, although in New Hampshire, New York and Pennsylvania the State Department of Agriculture co-operates in sampling or in publication or in both.

The controls are financed either by direct state appropriation, by a brand tax, or by a tonnage tax. The brand tax system is usually employed in the North Atlantic states, while the tonnage tax is common in the South. A direct appropriation is uncommon, since it unduly favors the multiplication of brands, a situation which from the view point of the consumer does not conduce to a healthy trade. The tonnage tax, while theoretically just, practically proves burdensome and unsatisfactory. The brand tax as a rule simply meets necessary expenses and on the whole works well. Its main disadvantage in a small state like Vermont is that it serves to curtail the sales of brands not widely used and doubtless to discourage the entrance of new companies, thus tending to lessen competition. Yet in view of the fact that in most states private purchases for individual uses are not affected by the law but are specifically exempted from the necessity of license, and that the undue multiplication of brands purely for competitive purposes and quite apart from any real agricultural needs is thus discouraged, one need not lose sleep over this phase of the matter.

THE DETAILS AS TO ITS CONDUCT IN VERMONT

The conduct of a fertilizer control differs in detail in the various states. The essential features in Vermont are the collection of the brand tax and its conveyance to the state treasurer annually in January; the sampling of the goods as found on sale in the hands of local agents in March and April; the analytical work in the station laboratory in March, April and May; and the publication of two bulletins, in April and in June.

Any company wishing to sell fertilizers in Vermont can do so provided it pays the required license fee. If it purveys only unmixed chemicals and crude stock no fee is assessed. It can furnish to its patrons directions for the mixing of these materials at home, but it cannot sell the ingredients in a mixed condition.

Individual buyers who choose unlicensed brands of mixed goods can purchase them where they will for personal uses, quite without regard to the license system; but they cannot resell them. Manufacturers make their own choices as to the brands they will offer. In some states legal restrictions are made as to the grade of goods, but nothing of the sort obtains here.

The goods are sampled in the hands of local dealers by agents of the Station, who use the standard coring device which takes a sample throughout the length of the bag. They are instructed to draw samples from at least five different packages of each lot. The samples are enclosed in parchment paper bags and these in sealed cartons. Duplicate samples are left with the local dealer at his request. Sub-samples of the originals are at the service of the manufacturers. The samplers' data include brand name, name and address of manufacturer, guaranty statement, selling price, date and location of sampling.

The guaranty statement required of the manufacturer covers the minimum percentages of nitrogen, of water soluble potash, and of soluble, reverted, insoluble, available, and total phosphoric acids. The law requires nothing else, save a maximum chlorin content a provision which is not enforced. Practically all manufacturers, however, add thereto many other figures, and also very generally state maximum percentages. All of this is unnecessary, meaningless, and often misleading. Buyers should shut their eyes to this extraneous and gratuitous information. The guaranty statement required by the Vermont statutes is similar in character to that required in other North Atlantic states. Taken in connection with the data furnished by the analyses it affords the buyer, if he takes the trouble to learn how these should be interpreted,[1] fairly detailed information as to the amounts of and the character of the several materials from which the goods are made, save and except as to the nature of the organic nitrogen.

The analytical work is done yearly in March, April and May, by the methods prescribed by the Association of Official

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[1] See statements further on in this article.

Agricultural Chemists. The analytical results are carefully scrutinized for possible error prior to reporting them to the manufacturers. Such a report precedes publication in order that any criticism which the manufacturer may make shall receive proper consideration. It goes without saying that such criticism, unless valid, has no weight. If the facts as stated by the Station are substantiated by resampling, re-analysis or otherwise, they are published, opportunity being afforded the manufacturer, if desired, to protest the results, the Station at the same time affirming their accuracy as representative of the goods as found on sale.

PUBLICATION

The tables of analyses in some states barely indicate the main items, the nitrogen, available phosphoric acid, and potash contents. It has been the custom here, however, to make such detailed analyses and publication as will enable the buyer who can intelligently grasp the meaning of the tabular matter to gather practically all the information needed to a wise purchase, in so far as chemical analysis can aid him to that end. From the tables he can determine not only the amounts but the character or "form" of the several ingredients. He can tell whether the manufacturer has used muriate or sulphate of potash as a source of this ingredient. He can determine whether the phosphoric acid is in a relatively available or relatively insoluble form; whether the nitrogen is in soluble or in organic forms and what proportions of each are employed. This information, together with the visual inspection of the goods, should serve to give him a fair notion as to the sources of the phosphatic material used, whether it be rock or bone. He cannot tell, however, with certainty the source or the availability of the organic nitrogen, which is the one great problem yet to be solved in fertilizer chemistry. Yet the results of inspection at this Station during the past ten years lead the writer to say that the use of inferior ammoniates in any large quantities does not appear to be common among the goods sold in Vermont.

The publication of the results of control work is governed by state law. In some states only the bare bones of the analytical work can be published, absolutely without comment of any kind, the law jealously guarding against any discussion or interpretation of analytical results. The well informed buyer can use such tabular matter to advantage, but the average buyer does not find it illuminating. In some states the exact form of publication is prescribed. The manner of the presentation of the data, particularly as regards the so-called valuations, is carefully laid down, but little being left to the discretion of the official in charge of the control. The Vermont statutes very wisely allow wide latitude to the director in this matter, the law at this point reading: "The results of analyses, together with such additional information in relation to the character, composition, value, and use of such fertilizers as circumstances may advise, shall be published in reports, bulletins, circulars or elsewhere as often as is deemed advisable." As a result of this broad provision the writer has for years been enabled to purvey as "additional information" much matter directly and indirectly dealing with the use of fertilizers and has tried so to interpret the analytical work as to make it of real service.

Many, perhaps most, fertilizer buyers make choices at haphazard. If they give the composition of the goods and the work of the control any thought at all, they doubtless reason thus: the Experiment station says that A's brands are all right, so it is safe to buy. The station's O. K. has reference simply to the maintenance of the guaranty. It is in no sense a certification of the fitness of any particular brand for the service it is supposed to render. The law requires the manufacturer to state a self-fixed standard. The station simply determines whether or not he has maintained in fact this self-fixed standard. Only this and nothing more, so far as the inspection goes. And in the "additional information" care is taken to refrain from indicating by name brands which are deemed to be advisable purchases. It is often asked to recommend in terms of the names of brands, the "best" fertilizer for a given condition, a request which it does not grant —in terms of names—but does answer in general terms, leaving the buyer to fit such terms to his special case. The reason for this attitude is so obvious as to call for no further comment.

DETAILED EXPOSITION OF THE ANALYTICAL TABLES

Explanations of the tables have been made in previous bulletins, but usually in a somewhat condensed form. The writer finds both from conversation with farmers and from experience in the classroom, that notwithstanding these explanations the true meaning of the tabular matter frequently is not grasped. Hence he deems it worth while now to explain these tables in extreme fullness and in as simple a manner as possible, perhaps at too great length, perchance with too great pains at clarity. But he prefers to err in over doing it. Choice is made for the purposes of illustration of the *second fertilizer listed on the second page of the table on page* 152, *being the American Agricultural Chemical Co.'s Bradley's Potato Fertilizer.* This choice is made purely for illustrative purposes, and is determined by two factors. In the first place it is easy to find it in the tables, and secondly the goods are of a medium grade and of a type widely used. The choice for this purpose should not be construed as a recommendation of this particular brand as a potato fertilizer. The writer neither affirms nor denies its fitness for this purpose. He chooses it, as already remarked, solely for illustrative purposes and nothing more. It is only a peg on which to hang his hat.

1. '*A5* is the first item to receive notice. This has simply reference to an arbitrary number used in the chemical laboratory during the course of the analysis serving to identify this particular brand. Neither this, nor, "A1,"—a phrase sometimes used to indicate quality—has any significance outside of the laboratory.

It is printed in the tables simply for purposes of identification and to make more certain that the analytical data as published is correctly transcribed from the record books.

2. *The name of the brand* is given in this column, in this case being the American Agricultural Chemical Company's Bradley's Potato Fertilizer.

3. The first figure in the analysis is 0.84. The column in which it appears is headed "*from nitrates*" and has in common with the next four columns, a general heading reading "Nitrogen." One should, therefore, read this piece of data as follows: Bradley's Potato Fertilizer was found to contain 0.84 percent of nitrogen or 0.84 of a pound in each sack derived from nitrates. This is equivalent to almost 17 pounds of nitrate nitrogen per ton ($0.84 \times 20 = 16.8$). Nitrate nitrogen is almost invariably derived from nitrate of soda. It is soluble in water and immediately available to plant purposes. It is ready to start foliacious growth at the earliest possible moment. It is prone to leaching under certain circumstances. It is, however, a most desirable ingredient for use on hoed crops, particularly in this latitude of short seasons.

4. The next figure is 1.33. The column in which it appears is headed "*from organic matter*" and is again headed "Nitrogen." Hence, one reads this item as follows: Bradley's Potato Fertilizer was found to contain 1.33 percent of nitrogen or one and a third pounds per sack derived from organic matter. This of course is equivalent to $1.33 \times 20 = 26.6$ pounds of nitrogen derived from organic sources. Organic nitrogen is obtained in fertilizers from animal sources (bone, meat, tankage, fish scrap, etc.) and vegetable sources (cottonseed meal, tobacco stems, castor pomace, etc.). It is also obtained at times from less desirable sources of supply (leather, garbage tankage, wool waste, hair refuse, etc.). The former as a class are readily available and yield up their nitrogen promptly. The latter as a class are less readily available, are even slowly available, and are less easily rendered serviceable to plant purposes. Herein, as has already been noted, fertilizer chemistry fails, in that it is unable with certainty to detect in mixed goods the presence of inferior am-

moniates. Any large usage thereof, however, can be discovered with reasonable surety by methods now in vogue, but the employment of small proportions can not be determined with certainty. (See page 141.) However, be it good or bad, readily available or slowly available, or partly one and partly the other, for better or worse there was found to be present in these goods this year 1.33 percent of organic nitrogen, the function of which is just the same as that of the nitrate nitrogen, that is to say, to force foliacious growth. It does it less promptly than does the nitrate nitrogen, but is not on that account to be decried. It leaches less readily. It is a standby for summer usage. It nitrifies (see bulletin 130, pages 234-244) and thus becomes available if derived from good forms of crude stock and if conditions favor. It is a most desirable ingredient. Rarely, if ever, should nitrogen for hoed crops be used solely in the nitrate form. A large proportion of it should always be of organic origin.

5. The next figure is printed in a different type, a plainer one, black faced, to give it prominence. This means that this figure is one of the more important ones. Only four columns are thus distinguished. It should be construed to read 2.17 percent of *total nitrogen* found (to be present in the goods as actually sold). This figure is simply the sum total of the two preceding figures, viz. 0.84 and 1.33. These latter show what kinds and in what amounts the nitrogen was present. The former —2.17—indicates the total amount present regardless of its nature. This total figure is of service in the determination of the validity of the manufacturer's guaranty, and in enabling the purchaser to arrive at a general notion as to the fitness of the brand for any particular service. One can also compare this figure for instance with the one immediately preceding it in the perpendicular column (i. e. percent nitrogen in Niagara goods) or with that immediately following it in the perpendicular column (i. e. percent nitrogen in Potato Manure goods) can thus determine at a glance the several amounts of nitrogen present and be thus

aided in the formation of judgment as to preferable choices, so far as the nitrogen content is concerned.[1]

6. The next figure again appears in different type which is also employed for emphasis. Italics are used in four columns and indicate *manufacturers' promises* made in accordance with the state law which requires (4976 P. S.) a statement of the minimum contents of nitrogen and the other ingredients. In this case the manufacturer's guaranty or promise to the buyer is that the fertilizer carries at least 2.06 percent of nitrogen or 2.06 pounds per hundred. It will be observed that the figures in the other italicized columns are whole figures or simple decimals, usually 0.5 percent. In the nitrogen column, however, the figures are peculiar fractions, 0.82, 1.03, 1.64, 2.06 being particularly common. This is due to two reasons. In the first place nitrogen is roughly five times as costly as are the other ingredients and hence is used by the manufacturers more carefully and sparingly than are phosphoric acid and potash, with closer attention to the smaller amounts and to the withholding of any considerable excess over and above the amounts guarantied. Then again, and the main reason for the oddity of the figures, the manufacturers buy and mix on the "ammonia basis," that is to say their purchases and their formulas according to trade custom are based on the content of nitrogen calculated as if it were all ammonia, even though

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[1] THE FUNCTIONS OF NITROGEN

"Each element used by plant life helps in the building of certain parts of the plant and likewise, doubtless, each has some one or more special functions. What some of these are is not well understood, but some are known.

Nitrogen is known to show its effects on plant life in three ways:

1. It promotes stem and leaf growth, and, if in excess, delays seed and fruit formation.
2. It deepens the green coloration of the leaves.
3. Its abundance may increase and its deficiency may lessen the relative amount of nitrogen in the plant. This means variation in food value.

If nitrogen is freely applied in fertilizers or is present in plentiful quantities in the soil, its effect is generally shown (unless its effect be negatived by phosphoric acid) by a vigorous, dark green leaf growth and by a somewhat retarded flower and seed formation. If available nitrogen is relatively lacking either in the soil or in the added fertilizer, a somewhat more scanty foliage than occurs under better conditions, one of a rather lighter green, is grown. The seed, moreover, is apt to mature rather earlier than usual. One may by careful observation judge somewhat as to the crop needs in this manner. It should be remembered in this connection that nitrogen is essential to plant growth, that available nitrogen is in small quantity and easily exhausted from soils, and that consequently it is and always has been the most costly form of plant food."—Bul. 99, p. 90 (1903).

it rarely happens as a matter of fact that any material portion is in the form of ammonia. Ammonia is a compound of two elemental gases, nitrogen and hydrogen, in the proportion by volume of 1 to 3, and by weight of 14 to 3. Hence 17 parts of ammonia by weight contain only 14 parts by weight of nitrogen. Hence we have the proportion 17 : 14 :: 100 : 82. The state law prescribes, as do similar laws in the other North Atlantic states, that the guaranty be of nitrogen rather than of ammonia; hence 0.82, 1.03, 1.24, 1.64, 2.06, 2.47, etc. are simply the expression in state law terms of 1, 1.25, 1.5, 2, 2.5, and 3 percents respectively of ammonia. Nitrogen is the proper term to be used in the expression of guaranties, inasmuch as it is the real unit, and because ammonia as such is not found to any extent in the generality of fertilizers. The statement of the ammonia content frequently found on fertilizer sacks is simply a part of that surplusage with which manufacturers are apt to bedeck the bags; in other words it is merely a piece of mathematical calculation.

In the case now in hand the manufacturers promised the buyer to deliver 2.06 percent nitrogen and was found by the station analysis to have kept their promise and to have delivered 0.11 percent more, or 2.17 percent in all.

7. The next figure is one which is open to much misunderstanding. It reads in full, $7.82 *valuation of nitrogen,* and the reader is referred by the ‡ to the definition on page 128. The reader is urged here to scan the matter on pages 128-130 and then to grasp these fundamental propositions, which in spite of reiterated repetitions couched in divers terms are still widely misunderstood. The valuation figure does not represent either:

The retail selling price:

The proper selling price:

The agricultural value, that is to say what it may be worth to the farmer in increased crops:

The worth of the goods commercially:

The agent's buying price.

The valuation figures mean only this and nothing more—that a man with cash in hand could have bought last fall or winter in Boston or New York 16.8 pounds of nitrate nitrogen in the form of nitrate of soda and 26.6 pounds organic nitrogen in the form, for instance, of dried blood or some similar hight grade product, for $7.82. "That's all!" The retail cash cost of unmixed, unbagged, unfreighted crude stock. The cost of ready made but not ready mixed plant food. Neither does the difference between the several valuations for nitrogen, phosphoric acid, and potash added and the selling price represent profits. The Vermont farmer paying $30 a ton for fertilizer delivered to him five miles from the railroad station does not only pay for plant food, but for its manipulation, its packing, its freighting, and the selling expenses; just exactly as when he buys a barrel of flour he pays not only for the flour—which is all that he really uses,—but for the barrel itself, the freight charges and the grocer's profit. The valuation has regard simply of the plant food content and of no other one of these necessary and fixed charges. Neither does it declare what the plant food in the brand under survey is worth or what it costs the manufacturer. It simply indicates the cash costs of equivalent amounts of plant food of good character.

8, 9, 10. These colums and all the others to and including 15 possess one general blanket heading—*"Phosphoric acid,"* which should be so construed as to be read with all the sub-heads. The first three of these sub-heads have to do with the form of the phosphoric acid; be it soluble in water and thus immediately available to plant growth; or reverted, that is to say in a form not soluble in water but more or less acted upon by plant and soil solvents, much, doubtless most, perhaps all, of it quite readily available to plant usage; or that which is insoluble (in water, in soil fluids, and in ammonium citrate, the chemical which is used in the laboratory for the removal of the so-called reverted phosphoric acid) and hence but slowly available to plant purposes. The term "reverted" means literally gone back or turned back, the conception being that some of the phosphoric acid once soluble in water has backsliden as it were to a less soluble condition. This is quite apt to happen to the soluble phosphoric acid when it is incorporated with the soil. Obviously the service for plant purposes of these three forms of phosphoric acid is diverse.

The figures in the three columns then should be read as follows: 6.04 percent of phosphoric acid which is soluble in water; 3.38 percent of phosphoric acid which, while insoluble in water, is notwithstanding quite readily available to plant and soil solvents; 2.94 percent of the phosphoric acid which is insoluble in either water or in plant or soil solvents and is only very slowly available. The soluble and reverted phosphoric acids are commonly obtained by the action of sulphuric acid upon ground phosphate rock. This chemical reaction serves to remove some of the lime from the insoluble phosphate, forming therewith gypsum, and setting free and rendering available the hitherto insoluble phosphoric acid of the rock.

11. This black faced figure, 12.36 percent *total phosphoric acid* found to be present, is the sum of the three phosphoric acids just separately enumerated and shown in columns 8, 9, and 10. All the remarks that were made in connection with the figure in column 5 as to total nitrogen hold here as well.

12, 14, 17. These italicized figures 10, 8, 3, constitute the *manufacturer's promises or guaranties* respectively for total phosphoric acid, available phosphoric acid and potash. In a general way the statement in the sixth paragraph concerning the guaranty for nitrogen holds here as well.

13. This figure, 9.42 percent *available phosphoric acid* found to be present, is derived by the addition of the soluble and reverted phosphoric acid contents, as shown in the columns 8 and 9. Inasmuch as the reverted phosphoric acid is held to be mostly, if not entirely, soluble in plant and soil solvents and consequently is deemed to be of service within a reasonable time for plant purposes, it is commonly lumped with the soluble under the general term of available phosphoric acid. This figure is in a way then the most important single phosphoric acid figure, inasmuch as it indicates that portion of the phosphoric acid contents of the goods which may be held to be readily available for

hoed crops. It will be observed that in the case now under survey both the total and available phosphoric acid contents as found by analysis exceeded the manufacturer's guaranties by wide margins.[1]

15. This figure $8.38 indicates the valuation of the phosphoric acid. The remarks made in paragraph 7 touching valuation obtain here.

16. This figure, 2.97 percent shows the *potash* content of the brand under survey. The absence of the * at this point, as well as at the station number A5 at the extreme left of the page, is indicative of the source whence the potash was derived. The indication is by inference only, but it holds notwithstanding. The foot note reads thus: "*Potash in brands thus marked is largely if not entirely as sulphate." The particular brand under survey not being thus marked, its potash is not of sulphate origin and, therefore, is necessarily derived from muriate or kainit or both. Both of these salts are quite heavily loaded with chlorin, an ingredient which for certain purposes and on some soils is not held to be a desirable one. Inasmuch as the law prescribes the

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[1] FUNCTIONS OF PHOSPHORIC ACID

"The phosphates, like the nitrates, are distributed throughout all soils, but available forms, in quantities sufficient to promote a large crop growth, are often lacking. This is particularly true in grain growing regions since grain is a heavy user of this ingredient. They are absolutely essential to plant and animal growth, entering more particularly into the bone structure of the latter.

Phosphoric acid is known to show its effect on plant life in three ways:

1. It helps plant nutrition in proteid building, etc.
2. It promotes maturity and seed formation.
3. It aids the transference of the proteids to the seed.

1. Certain nitrogenous bodies in the plant structure have phosphorus built into their structure as it were. Some of them seem to play very important parts in the life activities of the plant. A lack of phosphoric acid would obviously work ill in this respect.

2. Seeds and fruit contain more phosphorus than does any other part of the plant. They do not develop normally and the plant fails to mature unless a fair supply of this element is available. Phosphorus acts in a manner opposite to nitrogen in this respect. (See footnote p. 186). Phosphoric acid liberally applied early in the season, unless its effect be counteracted by plentiful supplies of nitrogen, hastens maturity. Plump, full seed indicates plenty of available phosphoric acid, while a shrunken seed or its failure to set may be due to its paucity.

3. Seeds and fruit are filled out by the transference of nutrients from the growing parts, stalks, foliage, etc., to the seed. Phosphorus aids certain nutrients to become sufficiently soluble so that they may pass through the plant structures to their destination. This function is obviously closely allied to the second one.

If phosphoric acid is freely applied in the fertilizer or is present in plentiful quantities in the soil, its effect is generally shown (unless this effect be negatived by nitrogen) by an early maturity and by well filled seed or fruit. The reverse occurs if the supply is scanty. One may judge somewhat in this manner as to crop needs."—Bul. 99, p. 93 (1903).

determination of water soluble potash, the figure does not show, of necessity, the total potash content. It will be observed that in this case the potash percentage fails to equal the guaranty statement by a minute fraction. The failure is so slight a one, however, (.03 percent or 6/10 of one pound per ton, a shortage worth possibly two and one-half cents a ton) as to be negligible. Moreover it is within the limit of experimental error; that is to say, a chemist cannot work so closely as to be certain not to get 3 percent or perhaps 3.05 percent in his next determination. Furthermore, the large excess of available phosphoric acid, nearly 30 pounds to the ton, quite outclasses this technical shortage. A shortage is not held to be truly such unless it is in excess of 0.10 percent nitrogen or 0.20 percent of phosphoric acid or potash.[1]

18. This figure, $2.52, indicates the *valuation* of the potash. The remarks made in paragraph 7 touching valuation obtain here.

Usually in publications of the controls of other states the valuation is expressed as a lump sum at the right hand end of the analytical statement. It has, however, always been the policy at this station to separate these figures and to print the valuations of the three ingredients each by itself, the more clearly to indicate their nature, the more certainly to point out that they find their origin in plant food contents of the goods rather than in the fertilizer as a whole. The purchaser who wishes to determine full valuations for comparative purposes has but to add together $7.82 + $8.38 + $2.52 = $18.72.

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[1] FUNCTIONS OF POTASH

"The known functions of this ingredient appear to be three in number.

1. It seems to be an essential to the formation and transference of starch in plants and thus indirectly in sugar formation.

2. It plays an important part in the development of wood structure and of the fleshy portions of the fruit.

3. It is in part a neutralizer of plant acids.

1. Starch is formed in the leaves of the plant through the agencies of the sunlight and the chlorophyll or green coloring matter. But starch is insoluble and cannot pass through the plant tissues. In some way not thoroughly understood it becomes sufficiently changed so that it can permeate the cell walls and thus be transferred to and accumulated in fruit, stalk, root, or tuber, where it becomes insoluble again. While the way in which this transference is brought about is not thoroughly comprehended, it is held that potash plays an important part therein and, also, that this ingredient aids in the original formation of the starch. No other constituent seems capable of replacing it, although others are associated with it, in this peculiar and extremely important function.

When potash is in the form of muriate (chlorid) the accumulation of starch more particularly at some one point, as in the tuber of the potato, seems to be somewhat interfered with. The tendency of chlorin seems to be in the direction of diffusing rather than of concentrating starch. This point has some bearing in the choice of the form of potash for the growth of different crops.

Since sugar is probably formed from starch the relationship of potash to its formation is obvious.

2. Starch is the mother substance of the wood. If it forms slowly the wood growth is inadequate. Starch occupies a very similar relation to the sugar, pectin and pectose bodies of the fleshy portions of fruit. Hence the relationship of potash to this matter.

3. Several of the plant acids, like the malic of the apple, the citric of the lemon, the tartaric of the grape and the like are in some measure neutralized by the potash which is taken up by the plant, it forming the most important base of the acid salts."—Bul. 99, pp. 95-96 (1903).

For further information concerning the valuation system see bulletin 99, pages 81 to 86.

WHAT USE MAY THE BUYER MAKE OF THE ANALYSES AND EXPOSITIONAL STATEMENTS OF THE FERTILIZER CONTROL?

1. He can compare the analytical results with the average analyses of fertilizers as sold throughout the State and judge whether the particular brand he contemplates buying is or is not of average quality.

Example. A so-called "high grade" brand which has sold for many years in Vermont is actually guarantied to contain less than 2 percent nitrogen and less than 2.5 percent of potash and 9 percent available phosphoric acid. Comparing these figures with the tables on page 136 showing the composition of the average fertilizer of 1908 and 1909, and upon pages 136-138, showing the average composition from 1895 to 1909, he can see that this so-called "high grade" fertilizer carries less nitrogen and less potash than has any average grade fertilizer in any one of these 15 years, while its phosphoric acid content, which is usually larger in low grade goods than in high grade goods, is merely normal. It is thus easy to detect the misleading nature of its name.

2. He can compare the analytical results with the manufacturer's guaranties and determine whether promises are made good.

Example. The nitrogen, total and available phosphoric acid and potash contents and the guaranties of three brands sold in 1908 are shown herewith.

	Nitrogen		Total phosphoric acid		Avail. phos. acid		Potash	
	Anal.	Guar.	Anal.	Guar.	Anal.	Guar.	Anal.	Guar.
A„	**2.03**	*2.45*	**10.18**	*9*	**7.70**	*8*	**5.93**	*7*
B,	**2.70**	*2.46*	**9.38**	*9*	**7.66**	*8*	**5.67**	*6*
C,	**0.88**	*1.03*	**11.84**	*10*	**9.56**	*8*	**2.17**	*2*

Comparison of analyses (black face) and guaranties (italics) show that all three brands were deficient to a greater or less extent. A careful scrutiny, however, discloses that there was a decided difference in the degree of the deficiencies. A is short in all three forms of plant food, B in two and C in one. A, being deficient everywhere, fails not only to furnish the proportions of plant food promised, but also the commercial or money equivalent of the plant food promised. B however, while failing to supply the full amounts of available phosphoric acid and potash promised, affords an excess of nitrogen. The excess of this latter ingredient, being from four to five times as valuable—commercially—pound for pound as the others, balances the shortages. Or, to make this statement more concrete, the excess of nitrogen over and above the guaranty was commercially worth about a dollar, while the shortages of phosphoric acid and potash hardly total sixty cents. The case is one of irregular mixing rather than of absolute shortage of all forms of plant food. In case A less than 90 percent of the total plant food content guarantied to be present was furnished. In case B, however, 101 percent of the plant food guarantied to be present was supplied.

C is like B only more so. But a single ingredient, nitrogen, in short of guaranty, and that but 0.15 percent. As an offset to this slight shortage the phosphoric acid is 1.5 percent in excess and the potash 0.17 percent, while the commercial value is considerably greater than that guarantied.

3. He can compare the analytical results with those of other brands and determine something as to their relative commercial values and also whether the plant food content has or has not been diluted with filler or make-weight.

Example. A brand carrying in excess of 3 percent nitrogen or of 7 percent potash and possessing a normal amount of available phosphoric acid can hardly be manufactured from anything but strictly high grade materials. Per contra, a brand carrying less than 1.5 percent nitrogen or less than 3 percent potash, if it carries over a normal amount of phosphoric acid, can hardly be made from standard high grade forms of crude stock unless they are diluted. However, certain forms of crude stock carrying rather low percentages of plant food,—such for instance as kainit, the highly phosphatic bone tankages, etc.,—are used sometimes in the lower grade goods. The use of fillers or make-weights as diluents is not a fraud; neither does it constitute adulteration. The buyer cannot expect a ton of high grade materials at the price of a low grade fertilizer. The goods are made to fit the price which is paid. The manufacturer may use fillers as freely as he desires provided his self-chosen guaranties are maintained. He breaks no laws, neither is he to be condemned.

4. *He may judge by comparing the analytical results with fairly well known standards, whether the name of the goods is such as to convey a false impression as to its fitness for a given purpose or crop.*

Example. It is quite common to find fertilizers branded as for some specific crop—for example corn, potatoes, grass and oats, etc. It is also common for the manufacturers to claim that these various goods are specifically adapted to the growth of the crops mentioned. A survey, however, of the following data shows the extremes in guaranties of brands, marked as for special purposes, as sold in Vermont this year.

Name of brand	Number of brands in the groups	Nitrogen	Available phosphoric acid	Potash
Potatoes,	38	0.8 to 5	4 to 9	2 to 10
Corn,	16	0.8 to 3.3	6 to 10	1.5 to 10
Grass and Grain,	7	0 to 8.5	3.9 to 11	2 to 12
Market Garden,	3	2 to 3.3	6 to 8	5 to 10

What tremendous differences between extremes. Shall the potato grower buy 0.8 percent of nitrogen or six and a quarter times as much? Shall he buy 2 percent of potash or five times as much? Shall he who would grow oats pay $30 a ton for the nitrogen content of a goods labelled "oats" or pay $0 a ton for no nitrogen in another brand also marked "oats," and sold by another company? The conveyance of false impressions is all too common in the fertilizer trade; yet the law does not prevent the manufacturer from naming his goods as he pleases. The several pure food and drug laws now common throughout the states meet this situation to some extent, but it is doubtful whether fertilizer enactments can be so framed as to cover it, although a national fertilizer enactment now in contemplation in its present tentative form aims to accomplish this end. It remains then simply for the buyer to inform himself as to his plant and soil needs and to be guided thereby, rather than implicity to trust to brand names. "Buyers," so writes one manufacturer to the writer, "prefer to see the word potato on the bags which are purchased for that crop and the word corn on those which are bought for the fertilization of that crop;" and stencils are cheap.

VIII SOIL PHYSIOGRAPHY[1]

INTRODUCTION

It is a settled policy at this Station yearly to "feature" some special topic in its main annual fertilizer bulletin. The law provides for the publication of "information in relation to the character, composition, value and use" of fertilizers. A somewhat complete survey of matters in close "relation to" the purchase and use of fertilizers has been made in recent years. Analyses have been printed, comparisons with guaranties instituted, and the relationship of selling prices and money values of the plant food contents discussed; valuations, guaranties and their meaning, brand names and their lack of meaning, the nature, sources and functions of the deficient elements of plant food have been considered; the several brands have been classified; the character, composition, application and use of farm manures have been reviewed; the systems and methods which prevail in the use of plant food have been outlined, and suggestions offered as to amounts and kinds for sundry Vermont soils and crops. All this has been done in the hope that such a survey might aid in placing Vermont farm practice upon a higher plane and a more rational basis. While it is necessary yearly to make and to print analyses and to comment thereon, and advisable annually to discuss the financial phase of the proposition, the special features of bulletins 93, 99, 108 and 116 (1902 to 1905) do not need repetition, at present at any rate, since these bulletins have been widely distributed and are still available on demand[2].

The more obvious and immediate matter "in relation to" fertilization having been covered, it seemed fitting in 1906 to begin to review matters less closely connected therewith; to pass from the consideration of artificial means of soil betterment to that of natural ones. Consequently the moisture relations of the soil, particularly as regards water control, through irrigation, drainage and adequate tillage operations, were discussed at length in the 1906 bulletin, No. 123. And, in pursuit of the determination expressed therein, to discuss "sundry phases of soil management during the next few years," a review was made in 1907 of soil biology as it relates to fertilization and particularly to the soil nitrogen content; and in 1908 of the causes and remedies of soil deterioration; of the methods of renovation; and of the ways by which further soil treatment may improve rather than impoverish; all with special reference to the humus content of the soil and its maintenance. In all these bulletins effort has been made to present the matter in as readable and popular a manner as possible, provided that essential accuracy of statement was not sacrificed.

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[1] This word, possibly a new one to some of the older readers of this bulletin, is the modern term used in lieu of the old time "physical geography," being derived by dropping the final and initial syllables of the two words and joining together the remainder.

[2] Bulletin 116 is largely called for but is available as a loan only, the edition being nearly exhausted.

In further pursuit of the determination above indicated it has seemed worth while this year to discuss at considerable length the fundamentals of soil making; the ways in which during the ages soil has been formed from rock and organic matter. The writer has not cherished the expectation that it would afford recipes suitable to agricultural practise; neither has he thought that the article would appeal particularly to the reader who has no use for matters which have not immediate practical value. He has felt, however, that it were worth while to tell the story of the making of the soil, particularly for the benefit of the rising generation. He who knows how a mechanism is constructed is the more likely properly to use it and to gain therefrom the fruition of its proper usage; and he who understands the way in which through the work of natural forces the soil has been formed, will be on that account the more apt adequately to cultivate it. Hence this article will doubtless have quite as much bearing upon the teaching of agriculture in the secondary schools as it will upon its practise upon the farm.

It has not always been found possible in the preparation of the special articles in the annual fertilizer bulletins to present them in as limpid a manner as could be desired. The subject matter, particularly of the article in bulletin 130 on soil biology and of the present article on soil physiography, has been necessarily too abstruse to admit of absolute clarity. It has been found quite impossible at times to avoid using technical terms for which there are no popular synonyms. On this account the discussion will often be found difficult for the lay reader to grasp. For the comfort of such are recommended the glossary—pages 246-254—defining these terms, and the general summary of the article which gives the essence of the entire matter—pages 242-244.

The writer does not pretend to be either a geologist or a physiographer. However, for sixteen years he has had to do with the general matters discussed in this article in class room instruction in soil management in the University, and has naturally, on this account as well as because of other interests, endeavored to inform himself of matters in this particular field and to some degree at any rate to keep abreast of the progress therein. Hence he may claim without undue egotism to have at any rate some second hand information touching this general subject. In his attainment thereof and in the preparation of this article he has leaned very heavily indeed upon the published writings of others and especially upon the following works:

Merrill: Rocks, Rock Weathering and Soils. Parts III—V. (1906).

Chamberlain and Salisbury: Geology, Vol. I. Geologic Processes and their Results. Chaps. 1-6, 9-11. (1904)

Salisbury: Physiography (unabridged edition). Chaps. 1-9, 13. (1907).

Shaler: Origin and Nature of Soils. U. S. Geol. Survey Rept. 12, pp. 219-345, (1905).

Merrill: The Soil: Its Origin and Kinds. Cyclopedia of American Agriculture (Bailey). Vol. I, pp. 324-342, (1907).

Clarke: The Data of Geo-Chemistry. Chaps 2, 3, 12. U. S. Geol. Survey, Bul. 330, (1908).

He acknowledges his particular obligations to the works of Merrill, Chamberlain and Salisbury, which he has found invaluable for classroom uses.

There is a decided dearth of bulletins or articles published either by the United States Department of Agriculture or the various experiment stations dealing with this particular phase of soil management. However a brief list is appended on pages 244-245. It is in no wise meant to be a complete bibliography and does not pretend adequately to cover or name all of the many admirable monographs put out by the United States Geological Survey which have bearing on this general subject.

DEFINITIONS

Soil may be defined in many ways according to the point of view. Its geological (physiographical), chemical, physical, biological, and economic definitions are very diverse. Each affords a different idea of this multi-sided mother of us all, and these several definitions taken together give a better all round conception of its origin and functions than does any one definition of more limited scope. Simple everyday things are often among the hardest adequately to define; and so it is with soil. The word is often thought to be synonymous with dirt, yet the latter is simply "matter out of place" while the former is usually matter in place, from whence comes and whither returns all life.

While the present article deals particularly with the elaboration of the geological, or physiographical, definition, several definitions from divers view points are given herewith as prefixes thereunto. Obviously the original—i. e. that which has to do with the origin of things—definition is one which must permeate each of the non-original definitions.

A definition of soil in respect to its origin (physiographical)

Soil is a loosely coherent, highly decomposed layer of mineral matter resulting from rock decay which furnishes food and foothold for plant and animal life, with which is commingled more or less organic matter, mainly of vegetable origin. (Merrill).

A definition of soil as to its purveyal of plant food (chemical)

A more or less weathered rock detritus commingled with organic matter, containing ingredients in various conditions of combination both organic and inorganic in their nature, which are serviceable, when made soluble, together with gases withdrawn from the air by the leaves and the water absorbed by the roots, in the sustenance of plant life.

A soil from a chemical point of view is essentially a storehouse of food for plant uses.

A definition of soil as to the physical environment of plant life (physical or mechanical)

A more or less weathered rock detritus commingled with organic matter, of varying texture, which in part through its moisture and warmth-holding powers and because of its more or less complete aeration enables plant life to gain foothold and to absorb food.

A soil from a physical point of view is essentially a medium for the transmission of moisture and plant food.

A definition of soil as to its bacterial content (biological)

A more or less weathered rock detritus commingled with organic matter, wherein micro-organisms, mostly bacterial in their nature, functionate, transforming raw materials into available plant food, reducing relatively complex molecules of animal and vegetable origin into simpler forms suitable to plant nutrition.

A soil from a biological point of view is essentially a theatre of life activities, a living entity rather than a non-living mass.

A definition of soil as to its relationship to human occupation (economic)

A more or less weathered rock detritus commingled with organic matter, wherein through chemical, physical and biological agencies—and particularly as the activities of these agencies are enhanced through adequate tillage, drainage and fertilization,—such environmental conditions are furnished as to afford adequate and profitable crop growth.

A soil from the economist's point of view is a national asset, to be economically employed, to be used and not abused, to be developed and not exploited.

SOIL ORIGIN

Soil results from rock decay. Soil is born of rock and, per contra, some rocks are simply consolidated soils. Sand, for instance, is mainly a disintegrated quartz rock; sandstone is often derived from sand, compacted commonly by pressure into rock. Clay is usually formed from decomposed feldspar; slate is commonly a clay molded into plates, usually by pressure and heat. Thus through the ages a given soil particle may have been in several forms. Originally existing as a solid rock it may have been broken down into soil, then again consolidated into a fragmental rock, and perhaps once again worn down into soil. Summer's heat and winter's cold, the air, the rain, heat, pressure, chemical changes; a multitude of agencies bear relationships to these disintegrations, these breakings-up, recombinations in endless round. The final result is the formation of a somewhat thin mantle or blanket of loose debris covering the original rock, which, when mixed with organic matter, is called soil, a material furnishing a living place for plant life and, indirectly, sustenance for animal life.

The mineral matter of the soil is formed from the rock as a result of the activities of the internal and external forces shortly to be described. That this is so is evidenced by the study of rock fragments and of soil analyses. Furthermore and still more convincing, the processes of soil formation are now going on and may be seen and studied. While soil, like Rome, is not made in a day, yet some soils have been formed from rocks within historic times, and so recently that the entire process may be reviewed. Thus for example, several of the lava flows on the slopes of Mount Etna, the dates of the exit of which from its volcanic crater are known, have become broken down and formed fertile soils on which vineyards are now growing.

The popular idea as to the world structure is that it is relatively stable. Yet this conception is incorrect, at any rate so far as it pertains to the exterior. Whole mountain chains of geological yesterdays have worn away and utterly disappeared.

Instability rather than stability, alteration rather than immobility obtains. Instead of "firm as the everlasting hills" one should say "change and decay in all around I see." Neither can the beginning of the process be apprehended nor its end be foreseen. It is at work today in some respects more rapidly than formerly. However, viewed in a larger and world wide way this entire proposition is really one of readjustment and involves no actual loss. The seemingly destructive processes of decomposition and erosion really in the end tend towards relatively more stable conditions. And after all the results are merely superficial, the various forces of disintegration being exerted only upon the surface, forming a scarcely appreciable film of soil overlying the unchanged rock.

Obviously rocks do not break down into soil of their own volition. Their decomposition is due to outside agencies, to dynamic forces of some kind. Several such functionate. They are classified as internal and external forces. No one of them is apt to act singly; as a rule several act collectively, though often some one or more may be dominant factors. Thus for example, a rock may be split by frost, honeycombed by water and finally broken down by the agencies of weathering; or all three agencies may act coincidentally. The final outcome—soil making—is thus the resultant of several different processes acting conjointly. The fact that they are separately discussed in this article should not be construed as indicating separate action. They are considered one by one simply for purposes of clarity.

INTERNAL AND EXTERNAL FORCES

The internal forces of rock disintegration and soil formation are:

I. Vulcanism (volcanic action). Pages 203-204.

II. Diastrophism (movements of the earth's crust, either rapid, as earthquakes, or slow, as the formation of mountain chains, etc., or as seen in the slow elevation or depression of the seacoast). Page 204.

III. Rock metamorphism (change in the physical or chemical character of the rock structure, as for example the change of limestone into marble). Page 204.

The external forces of rock disintegration and soil formation are:

I. Atmosphere (acting chemically to alter the composition; mechanically by dust or sand blast to wear away and erode; and by temperature changes to disrupt). Pages 205-209.

II. Ground water (acting chemically to alter the composition or to dissolve; mechanically to cause creeping or downward movement; and when super-heated to dissolve and deposit on cooling). Pages 209-215.

III. Water in motion (acting mechanically to erode or abrade). Pages 216-229.

IV. Ice (acting as a glacier, either ancient or modern, to erode). Pages 230-236.

V. Life (acting through life processes). Pages 236-244.

INTERNAL FORCES

The internal forces as a class were doubtless particularly active in earlier geological days, when, according to the theories now held, the earth crust was more flaccid than it is at present and crustal movements of various kinds, particularly volcanic outbreaks, were more frequent and violent. They are now and doubtless for ages past have been less potent factors in the making of soil than are and have been the external forces. For this reason, as well as because of limited space, only the briefest statements are made concerning them. Students interested in this particular phase of physiography should consult some of the many good text-books or special monographs.

1. *Vulcanism* (volcanic action). This process includes not only volcanic action as such, but in the earlier days the rise of volcanic (igneous) rocks from the lower to the surface levels.

The active volcano emits lava, a molten rock which tends to cool in irregular masses of open texture; ashes, which are simply a very finely divided rock; and pumice, which is a rock of a honeycomb structure. A rock is the more readily broken down and its constituents the more readily made available to plant uses—other things being equal—in proportion to its porosity, or its state of fine sub-division. This is a prime reason why volcanic ejecta rapidly form fertile soils. For example, the soils of the Hawaiian Islands which are notably rich and grow maximum crops are of volcanic origin. Similarly a large area of the most fertile soils in Oregon are of ancient volcanic origin.

2. *Diastrophism* (crustal movements). The various movements of the earth's crust, be they quick or slow, are of service in soil making, more particularly in that they tend to keep the rock structure near the surface in a state of more or less tension, a strain which tends to favor fracture; and a rock which is broken as compared with one which is unbroken tends to disintegrate. Of course only in a large way and during great lengths of time has this factor functionated. The force which has upheaved mountain chains and sunk most of the original Australasian continent below the sea is one to be reckoned with in soil making, viewing it in a large way. But there is no reason to believe that it has been a matter of major importance within historic times.

3. *Rock metamorphism* (change of texture or composition of rock either through the agencies of pressure, heat, water, or chemical affinity). Metamorphism means simply reconstruction, the rock changing in structure and sometimes in composition through the action of various agencies. The change of limestone into marble, for instance, does theoretically tend to promote to some extent the disintegration of the changed rock, for the reason that a crystalline structure is more apt to break along the line of the facets and thus crumble than is an amorphous structure.

EXTERNAL FORCES

The external forces are the ever active, everywhere present, non-spectacular soil making agencies of nature. Volcanic eruptions and earthquake devastations are infrequent. At times they are most effective, but ordinarily they are quiescent. But the air and the water, the wind and the wave, the ice and the frost, are always at work, quietly, effectively, unceasingly. No union hours limit their efforts. Hence their activities bulk large in nature's plan. They are the great pulverizers, dissolvers, eroders, the great soil makers.

I. ATMOSPHERE

The air acts both chemically and mechanically upon rock structure; hardening it here, disintegrating it there, changing its composition elsewhere, wearing away in yet another place. As a main agency in temperature changes it plays an important part in rock fracture. And, finally, were it not for aerial action the various forms of water, rainfall, river flow, glacial movement, could not act.

The air is everywhere in contact with the soil and the surface rock. It penetrates both to some little depth. The part it has played in the earth's history is comparable to that of water, although its mass is less and the evidence of its work not as obvious. Unsubstantial as compared with either earth or water, its great mobility compensates for its lightness. Its effects are many and varied, the main ones, so far as the matter now in hand is concerned, being:

A. Its chemical activities.
B. Its mechanical activities.
C. The conditions it furnishes for:
  a. Temperature changes.
  b. Evaporation and condensation.

A. CHEMICAL ACTIVITIES

(a). *Nitrogen compounds.* Roughly four-fifths of the air consists of elemental nitrogen. As such it is inert and chemically does not attack rock structure. As ammonia or as nitrous or nitric acids, which form in the air in minute quantities, it probably has some slight effect.

(b). *Carbonic acid gas* (carbon di-oxid) is a constant constituent of the air in the proportion usually of about 280 parts per million. Near large cities the amount increases, while over forest areas it is lessened. Animal life, the combustion of coal and other fuels, and the slow decomposition of organic substances tend to increase its volume; the activities of plant life, to lower it. The rain sweeps much of it from the air and carries it dissolved in the water into the soil. Its solvent powers as a dry gas are slight, but when soil waters become carbonated they become potent solvents.

(c). *Oxygen.* About a fifth of the air consists of this active element. When in dry state, however, it is not particularly effective; but when dissolved in water it is a very active agent of destruction as will be noted later. (See page 212).

B. MECHANICAL ACTIVITIES

The eroding effects of wind blown sand and dust are often severe. Dust is carried easily and for great distances; sand, less easily and for shorter distances. The heavier and sharper sand particles naturally do the greater eroding work. The relationship of dust to soil making is shown more particularly in the formation of soils built up from its multitudinous particles.

Dust. Even the stillest air is never free from dust. Countless myriads of dust particles dance in city air, and hundreds float in country breezes. There are said to be over four billions of dust particles in a puff of cigarette smoke. More are found over the land areas than over the sea; more in lower than in high altitudes. They scatter the sunlight and are the cause of the blueness of the sky since in a dustless sky the bright sun would shine out of the black heavens. The tints of sunrise and of sunset are due to the dust in the air. Every raindrop is formed and every snowflake is crystallized about a dust particle.

Dust is due both to nature's and to man's activities. It consists simply of small particles of solid matter held in suspension in the air; fine bits of soil, tiny bits of lava blown high into the air by volcanic action, particles of dung, smoke, pollen, spores, organic residues in general. Dust floats, notwithstanding its usual mineral origin and in spite of being heavier than air, because the surfaces of the particles are large in proportion to their mass, thus increasing friction and augmenting buoyancy, and because of the ever present wind currents. So completely does the air distribute its dust loads that it is said that every square mile of the earth's surface of land area has contributed dust to every other square mile. Since the sea does not yield up its dust the tendency of the mechanical action of the air, so far as it relates to dust distribution, is to lower land surfaces. Dust transportation is especially active over dry surfaces, which are nearly free from vegetation and over which strong winds play. Where the soil is moist or bears a vegetal covering it is less readily moved.

Immense areas of soil, taking the world as a whole, are of dust origin; for instance, large sections of some of our prairie states, whole provinces in China, and in many other sections of the world. Inasmuch as dust is necessarily fine textured and since soils of a fine texture for this reason are apt to be fertile, it follows that dust soils are commonly of high quality.

Sand. Sand only blows when dry. It is not carried as is dust, nor does it remain as long in the air. It is more apt to be stopped by obstacles, by trees, fences, buildings, etc. It forms mounds like wind-blown snow. In many sections, particularly along the seacoast it forms dunes, which advance under the influence of the wind and sometimes envelop and overwhelm buildings, orchards, etc.

The abrading power of sand is well understood. Its continual impact in arid regions or on sandy coasts does much work. The illegible tombstones in Trinity (New York) churchyard are scoured by the dust and sand of the streets. Cliffs and boulders are thus undercut; entire outcrops are worn away; many of the freak landscapes of arid lands, such as are seen in the Garden of the Gods in Colorado, are thus caused. Sand not only wears the surface against which it impinges but the grains themselves become worn and reduced to a finer condition.

Wind erosion in brief removes fine materials already loosened, and lowers the surface from which they are removed. These materials in transit grind down the rock surfaces against which they strike, and they themselves suffer from the impact. As a world wide process, it is an important factor in the wearing of rock and consequently in soil formation.

C. TEMPERATURE CHANGES

Heat expands and cold contracts. The expansion and contraction of rock structure caused by temperature changes tend to weaken and ultimately to disintegrate it. Rock is a poor conductor of heat. Its surface heats and expands more readily than does its interior. Hence strains are set up between the surface and the interior, both when heating and when cooling. This results sometimes in what is known as the exfoliation of rocks, which causes the surface of boulders to peel off very much as the outer layers of an onion may be removed. Rocks are not ordinarily made up of a uniform mass, but are composed of many minerals, each one of which may have a different rate of expansion and contraction from that of the others. Then as the rock heats up under the sun's rays, each particle expands and tends to crowd its neighbors. As the temperature lowers each contracts. Particularly in arid lands where temperature changes are rapid, the rocks become quickly heated and quickly cooled, resulting in an almost constant stress and strain, enough to produce decided weakening and to open up cracks and fissures, within which may work other agencies of weathering, such as water and frost. Cement sidewalks sometimes bow upwards and break from this cause, and the floors of rock quarries, etc. are thus fractured. But its effect is particularly seen in high altitudes and latitudes. Great masses of rock broken up in this fashion are found in mountain regions where sudden changes of temperature occur. In the colder climates such manifestations are very common. The broken fragments may be of miscroscopic size or may weigh tons. They sometimes burst with a report like a cannon.

Frost. Where frost has an opportunity to work the results are striking. It is well understood that water expands in freezing. Its expansive force is said to be equivalent to about 150 tons to the square foot. Its effect in bursting water pipes is well understood. When, therefore, water works into rock crevices and freezes, it is apt to split the rock. The sloping mass of mingled rock debris and soil—the talus—which lies at the foot of practically every upright cliff in regions where frost acts is usually due to frost action.

No rock is entirely impervious to water. The hardest granite may carry as much as 0.40 percent. When this so-called quarry water freezes it produces a slight stress; and year in and year out, through winter's cold and summer's heat, new rifts are opened and old ones widen, more water enters, and in the course of time disintegration occurs.

EVAPORATION AND CONDENSATION

The service of the air as a medium for the circulation and distribution of water is important. Its temperature governs evaporation and controls condensation and rainfall. All that is said in the next several pages touching the relationship of water to soil making might properly be included under the general heading of atmospheric effect, since aerial conditions determine the size of rivers and of glaciers.

2. GROUND WATER

As has been just indicated the ground water reaches the soil from the air. The average rainfall in the East ranges from forty to sixty inches. The distribution of this precipitation, however, is extremely uneven. In some places it is heavy, in others light; in some there is relatively more rain, and less snow; in others, the reverse. The amounts of rainfall and of snowfall determine the size and distribution of streams, glaciers, etc., which are important factors in the molding of land surfaces.

Every rain drop does mechanical work.

(*a*) It washes dust, spores, nitrates, nitrites, ammonia, etc., from the air loading these onto and into the soil. In the course of time considerable quantities are thus brought down.

(*b*) Each drop strikes a blow. If on vegetation, it has but little effect. If, however, it strikes the soil it moves the soil particles, which produces friction and wear, and serves to make them on that account the finer. Each individual blow of course does an inconsiderable amount of work; but the multiplicity of blows has effect.

(*c*) It causes the expansion and contraction of clays, increases the coherence of sand and dust, and lessens their erosion.

(*d*) Finally when united with other drops, as will be noted later on, it does chemical and mechanical work.

Rain water disappears—

(*a*) Below the surface.
(*b*) Into pools, lakes or the ocean.
(*c*) Into streams.
(*d*) In evaporation.

The proportion lost by these various channels depends upon conditions, particularly upon the surface topography, the rate of the rainfall, the porosity of the soil and its prior saturation, the vegetal covering of the soil, and the humidity of the air. The more rapid the slope, the greater the proportion which escapes by flowing over the surface, the so-called "run-off." Sandy soils tend to promote percolation or absorption downwards of the rainfall into the soil and thus to lessen the amount of the run-off; while with clay soils or such as are frozen or saturated with water, the reverse is true. A verdure clad soil restrains the run-off. The soil conditions which tend to favor percolation and to furnish an ample supply of ground water are a somewhat heavy rainfall, falling slowly upon a relatively level soil of open texture underlaid with porous rock.

Much of that water which enters the soil by percolation and thus constitutes the ground water, reaches the surface again either by direct evaporation from the surface of the soil, by absorption by the plant roots and transpiration from the plant leaves, by way of springs or wells, or by working out from underground into seas or lakes. The surface of this ground water, the so-called "water table," is coincident with the surface of the soil in ill-drained regions; but in well-drained fields is more or less below it. In agricultural regions, however, it is rarely more than a few score feet below the surface. It is apt to undulate, somewhat but not exactly, in accordance with surface contours. It is a continuous sheet between soil particles extending over vast areas of territory and subservient largely to the influence of the force of gravity. It is in more or less constant movement because of well pumpings and flowing springs as well as on account of the action of capillarity, plant root action, leaf transpiration and surface evaporation.

Ground water does three classes of work:

A. Chemical.
B. Mechanical.
C. Thermal.

A. CHEMICAL WORK

Four classes of chemical work are recognized:

(*a*) Oxidation. (*b*) Deoxidation. (*c*) Hydration. (*d*) Solution and deposition.

(*a*) *Oxidation* (rusting) affects more particularly rocks which contain iron. This metal when oxidized crumbles into ordinary iron rust, which is of course friable. This serves to honeycomb the rock and to make it more readily acted upon by other weathering agencies. The red soils found in many sections of this country and elsewhere, and the red hues commonly observed throughout the Rocky Mountain regions testify to the oxidation of iron. This action is mainly due to the oxygen of the air dissolved in water. Rocks thus acted upon tend to crumble, gradually to decompose and to fall away.

(*b*) *Deoxidation* (the removal of oxygen) is less common than is oxidation. It is particularly apt to occur in swamps and in places where organic matter is rapidly undergoing oxidation. Under such circumstances oxygen is usually withdrawn from the mineral in order to oxidize the organic molecule.

(*c*) *Hydration* (the working of water chemically into the rock) is very apt to accompany oxidation. The incorporation of water into the molecular structure of a rock particle tends to cause it to increase in size and to burst or split.

(*d*) *Solution and deposition.* Water is nature's greatest solvent; but if perfectly pure is a poor one. Pure water, however, rarely exists in nature. It is almost invariably contaminated with oxygen and carbonic acid gas derived from the air, and with more or less salts, originating in the organic matter and soil minerals. Though a universal solvent it acts slowly with results ordinarily not appreciable at once; but in the course of millions of years it does marvellous work.

The destructive effects of water in which oxygen, carbonic acid gas or minerals are dissolved are not always readily apparent because the materials it dissolves are removed. It is stated that some soils only a foot thick really represent from 75 to 100 feet of original limestone rock, the rest of which has been worn away mainly by solution. It is estimated by Merrill that some 275 tons of calcium carbonate (limestone) are annually removed from a square mile of exposed limestone in the Appalachian region. An English authority considers that there are nearly 150 tons removed per square mile in certain portions of England; and he calculates for the world as a whole an average removal by solution of this one ingredient alone equivalent to 50 tons per acre, together with 46 tons of other materials, mainly gypsum, ordinary salt, and sundry alkaline carbonates and sulphates. Gypsum is extremely soluble, limestone is decidedly so, and other rocks less so.

That solution has been an important factor in rock disintegration and soil making is evidenced by many well understood phenomena. The ocean is salt and springs and well waters hard, because of the solution of minerals. All the larger caves of the world are formed in limestone rocks because of their ready solubility. The stalactites and stalagmites, lime icicles as they are sometimes called, are evidences of solution and of evaporation.

Solution is usually and naturally most effective near, but not at, the surface. The outer rock structure is usually composed of materials somewhat less soluble than those below, for they represent as a rule residues from which the more soluble portions have been removed in past ages. It is said that a third as much material is carried to the sea in solution as is borne in suspension (see page 220), and that processes of solution tend to lower land areas about one foot in 13,000 years.

The action of water now under survey in its relation to soil making really involves three quite distinct processes—subtraction, substitution and addition. The first involves a withdrawal of mineral matter, the remainder rock being more or less porous. The amount dissolved of course varies with the kind of rock, the purity of the solvent, its amount, etc. Substitution simply involves the exchange of certain minerals for others; for instance carbonate of lime (limestone) removed by solution, some other material being built in, very much as a dentist fills a tooth. Addition involves the withdrawal of materials from one place to another. Thus the material which is inlaid in dentist fashion is removed from its original location to be built in another. In other words, mineral matter can be deposited only if it has been previously dissolved.

The deposition of dissolved matter in soil bears a close and obvious relation to its plant food content. It may be caused either by evaporation, by the cooling of the fluid carrying the dissolved matter, by the reduction of pressure, by the escape of gas, by the action of algae, and by chemical reactions. It may occur wherever water reaches rock structure, but is most common either deep below the center of active solution, or upon the surface.

B. MECHANICAL WORK OF GROUND WATER.

A water-logged soil, particularly on a slope, is apt under the influence of gravity to creep or in serious cases to slide. The relationship of this phenomenon to soil making is only incidental.

C. THERMAL WORK OF GROUND WATER

The thermal springs, more active in earlier geological times than to-day, bring to the surface large amounts of dissolved rock material, a process which doubtless in bygone ages has been a factor in the matter now under survey. Their numbers to-day are not large and their action relatively unimportant.

WEATHERING

The result of the several atmospheric processes, chemical, physical or those dependent upon temperature changes (pages 205-209); of the sundry effects of the ground water, chemical and mechanical, (pages 211-212); and of plant life, (pages 236-242); all these, termed in a broad way "weathering," conspire so to alter the surface rock structure as to cause it to waste away, to become disrupted, to decompose, and to become loosened, thus favoring its ready removal by other and more powerful agents. Weathering tends to produce a blanket of earth over the rock bed. If the dominant weathering process is mechanical in its character. the more finely divided materials as well as the coarser materials are still rocky and of unchanged chemical composition. If, however, chemical factors have been dominant, the residue consists mostly of insoluble portions not dissolved and carried away.

This general term, weathering, covering a multiplicity of effects, is a most important process. Most soils consist mainly of weathered rock structure. Were rock not weathered there would be no soil. The weathering processes help the wind and running water to transport. Weathering, water solution and water erosion are the main factors in soil formation so far as relates to its mineral portions.

Rock weathering manifests itself in many ways. The climate and the mineral composition of the rock are the main factors determining the character of the outcome. This may be immensely varied one place with another or one class of rock with another. The ultimate results, however, are usually the result of a commingling of many processes.

The rate of weathering, be it rapid or slow, is affected—according to Merrill—by differences in the texture and composition of the rock, by the moisture of its surroundings, the position which the rock occupies, its source, be it eruptive or sedimentary, by climatic conditions, and other factors. A cold climate tends to disintegrate rock; a warm one, to cause its decay and decomposition. The former is a mechanical process, largely the result of frost work; the latter a chemico-biological process, brought about by chemical changes and life activities.

The thickness of the surface layer of this weathered material varies greatly. However, it is rarely in excess of one hundred feet and usually very much less. It simply represents the excess of destruction over transportation. If, for example, one hundred depth units have been disintegrated and the equivalent of eighty of these have been removed by the action of water in motion or otherwise, the disintegrated rock—the soil—would represent twenty units. Since, however, over most land areas a blanket of soil covers the rock, it follows that usually the weathering effects exceed those of removal. On the other hand, however, since both by chemical and mechanical means, i. e., solution and erosion, immense quantities are transported to other regions, it follows that the soil residue which overlies the rock may, as a matter of fact, represent the destruction of a depth of rock very many times the present depth of the soil.

3. WATER IN MOTION

Perhaps the most powerful of all the agencies in rock disintegration and soil formation is water in motion. This in a way is simply transformed sun power, in that the sun draws the water to the clouds whence in falling back again to the ocean level it exerts its power.

It were a theme for Walt Whitman: The ceaseless round of the raindrop from cloud to rill, to river, to ocean, and back to cloud again; from the heavens back to the earth; from its lowly estate back again to the heights; forever at work in multitudinous ways, revolving the wheels of industry, turning night into day, generating vast power, making soil and marring soil, degrading the land below the sea; as a solid, as a liquid, and in gaseous shape, the great transformer of nature.

The amount of water in motion defies calculation. An annual thirty-inch rainfall, which is less than the average in New England, is equivalent to more than a half mile depth in a hundred years; and "a thousand years in thy sight are but as yesterday when it is past." It is said that the world's rivers pour annually into the sea 6,500 cubic miles of water. It is also said that the average land elevation above the sea is half a mile. These 6,500 cubic miles drop then half a mile on the average from the time that they fall from the clouds to the earth until they flow into the sea. The same energy is exerted in this fall as would have been exerted had an equivalent amount fallen perpendicularly, notwithstanding the fact that it is exerted at an angle. This energy is largely expended in wearing away the sides and the bottoms of valleys. It is a force which produces great effects; doubtless the most powerful of all the agencies in soil formation. "Every raindrop beating down upon a surface already sorely tried by heat and frost, serves to detach the partially loosened granules, and, catching them up in the temporary rivulets, carries them to the more permanent rills, to be spread out over the valley bottoms, or perhaps, if the slopes be steep and the current accordingly strong, to the rivers and thence to the sea. The amount of detrital matter thus removed from the hills and spread out over valley and sea-bottoms quite exceeds our comprehension, but it is estimated that at the rate the Mississippi river is now doing its work, the entire American continent might be reduced to sea-level within a period of four and half million years * * * But the rivers like the winds and glaciers in virtue of this load they bear, become themselves converted into agents of erosion, filing away upon their rocky beds, undermining their banks, and continually wearing away the land by their ceaseless activity. The pot holes in the bed of a stream, formed by the swirl of sand and gravel in an eddy, furnish on a small scale striking illustrations of this cutting power, while the rocky canons of the Colorado of the West, where thousands of feet of horizontal strata have been cut through as with a file, show the same thing on a scale so gigantic as to be at first scarce comprehensible" (Merrill).

Water in motion, that is to say stream water, is derived mostly from the run-off of the ground water. Some of it of course comes from ponds, lakes, snow fields, glaciers, all of which gain their water originally from rainfall or snowfall. Hence it is that all the water comes from the air. The direct connection between the rainfall and the river is well understood. Every permanent stream flows in a valley the size of which bears relationship to the size of the stream. The valley is the child of the stream. Valleys are born, grow through youth to maturity and to old age, pass into senility, and die; that is to say they are cut narrow, broadened out, flattened out and finally are degraded to a plain. These changes are mainly due to the errosive effect of the stream which flows through them. The material which is thus worn away furnishes soil for regions farther down stream or is borne oceanwards. The tendency of such streams is to carry the eroded material into the sea,, to develop flats which are wider and lower the nearer they are to the outlet.

A. EROSION

The term "erosion" is used physiographically in two different senses; in a broad way covering the sub-processes of weathering, corrasion, and transportation, and in a narrower way as applied to corrasion only. The broader, and at the same time the more correct, view covers all those processes whereby earthy matter or rock are loosened and removed from one place to another, including everything tending to that end from the initial act which begins to disrupt it until the free particle is on its way. The narrower, less correct but more common, usage restricts it to the processes of removal only or to the results which such processes entail. The broader conception implies not only the processes of weathering (hitherto discussed) which loosen, but also those exhibitions of force which wrench the loosened particle from its bed and then bear it away to a greater or less distance. It does not, however, cover the deposition of the freed particle.

Defining now more exactly the three sub-processes cited above, as a precedent to the more extended consideration of the complex result of rock and soil transformation called erosion, it may be said that:

(*a*) Weathering is a general term applied to the sundry mechanical and chemical processes tending to loosen or change exposed rock surfaces as indicated at greater length on pages 214-215; that

(*b*) Transportation is the process whereby the wind, rain-wash or stream move the weathered particles; that

(*c*) Corrasion refers to the wearing effect produced in the stream bed by running water, either through its power of solution or by the frictional impact of weathered fragments in transit, or both.

The term erosion, therefore, is a blanket term. It covers all the many atmospheric and ground water activities already discussed (pages 205-209). It makes use of the life agencies yet to be considered (pages 236-242). These are the agents of weathering, and weathering is a part of erosion. The more active agencies of rock disintegration about to be reviewed, the abrading of wave, of river, and of glacier (pages 222-225) are also thus covered, being due to corrasion.

Erosion may be either constructive or destructive; constructive in so far as it makes soil through rock disintegration; destructive in so far as it removes soil already made and usable to other places or out to sea. Both phases are important, and the latter is disastrous. Few agricultural problems are more fundamentally important than that which confronts the nations of the earth in the matter of the control of destructive erosion. The relation of this matter to soil deterioration and the remedies therefor were discussed in bulletin 135, pages 148 to 150 and 160, and need not be again considered here save indirectly and briefly on pages 220-221.

B. TRANSPORTATION, A SUB-PROCESS OF EROSION

Transportation, the second phase[1] of erosion, is that agency which bears the loosened particles to other locations. The mechanically transported sediment is either rolled along the bottom of the stream or carried in suspension. The ability of a stream to transport sediment depends on its size, the amount and distribution of the rain and snowfalls, the size and contour of its drainage basin, and the character of the soil and rock. Obviously the larger the river and the greater its drainage basin—other things being equal—the greater the sediment transportation. The greater the rainfall and the more uneven its distribution, the greater the transportation. A forty-inch rainfall evenly distributed throughout the year does not cause as serious erosion as does one which is unevenly distributed. The contour of the drainage basin naturally affects erosion. If it be narrow and steep the results are different than if it be broad and level. If the rocks are of granitic origin less material is eroded and dissolved than if limestone preponderates, or if the rock readily crumbles.

The transporting ability of a stream is said to increase as the sixth power of its velocity; that is to say, its motive power is increased sixty-four times if its velocity is doubled. Thus a stream barely moving a sixth of a mile an hour can carry fine clay; if one-third of a mile, it will lift fine sand; two-thirds of a mile, it sweeps along fine gravel; one and one-third miles an hour, it may roll along inch pebbles; two miles an hour, it can sweep along stones as large as an egg. Naturally the size of the stream, the character of the river bed and other factors affect its moving power. In other words it does not follow that transporting power and transportation are synonymous terms, since the latter depends upon the materials to be moved as well as upon the rush of the waters. For example, the Niagara river at the whirlpool rapids is a stream of tremendous transporting power, but it carries but little, for the submerged rocks are clad with slippery algae which protect them from wear; and moreover there is no sand or mud borne in the stream to act as abraders.

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[1] The first phase, weatherng, is discussed under 2, ground water, pages 214-215.

How is sediment transported? The gravel and the coarser sand grains are moved near the bottom by the impact of the water. Silt and mud are carried in the body of the flow. These mineral products weigh from two and one-half to two and three-fourths as much as water. Why then do they not sink? Why should they be buoyed up in the body of the stream rather than fall to the bottom? This anomaly is explained by the fact that a particle of sediment in running water is subjected to three forces; one which impels it onward—the moving stream; one which draws it downward—gravity; and an irregular one which tends to whirl it in several different directions due to stream currents, eddies, etc., caused by its varying velocities, the unevenness of the river bottom, etc.

Rivers carry two loads; a visible one consisting of the debris in suspension and rolled along the river bottom, and an invisible one consisting of material in solution. Some carry but little visible load; all carry invisible loads. The former is often immensely heavy. The muddy waters of every turbid spring freshet indicate its destructive powers as a soil remover. Rivers flowing through alluvial plains are always mud laden.

Below Mason and Dixon's line, and throughout the Mississippi Valley, practically every river is mud laden because of erosive action. It is calculated that the Mississippi carries annually seawards over a million tons daily of suspended matter; a yearly loss equivalent to seven billions of cubic feet; enough to cover over 250 square miles of territory a foot thick; equivalent to 900 train loads of fifty 25-ton cars each daily or a continuous train of cars running day and night at fifteen miles an hour; and it is further calculated that the Mississippi carries seawards but perhaps a fortieth of what all the rivers of the world are thus carrying; and furthermore that its invisible or dissolved load is at least a third as great as its sediment load. Clearly the tendency of water in motion is to degrade the continents to and below the level of the sea, a work which is constantly going on and which in the course of millions of years is likely to be accomplished. It is calculated that the total mechanical and chemical denudation of the land (these being the scientific terms for the work of the rivers in carrying their visible and invisible loads) would reduce the American continent to sea level in from four to seven millions of years. (In this connection see bulletin 135, pages 148-150).

The rapidity of this form of erosion varies according to the volume and the velocity of the water, the character of the surface over which the water flows, and the amount and character of the load. The water volume naturally depends upon the rainfall and the drainage area; its velocity depends upon the slope, on the volume and the depth of the stream, upon the load which it carries, and upon the shape and the contour of the channel. The relationship of slope to the rapidity of erosion is obvious; likewise of the volume of water. It is well understood that a rapid flowing stream has more power than has a slow moving stream, and that the full stream carries more than does the stream at low water. The visible load is a burden. The more the load the less new load can be picked up, for the energy which is used in carrying it would otherwise be used in the act of flowing. A smooth or deep channel is obviously more favorable to speed of flow than is a swift or broad one, because of lessened contact and lessened friction. The material thus moved is not all lost. Some of it is simply transferred from one point to another. So far as the world as a whole is concerned none of it is lost, but much of it, particularly that which goes to sea, is lost so far as agriculture is concerned. A river picks up or drops sediment according to sundry conditions as indicated later on under deposition.

C. CORRASION, A SUB-PROCESS OF EROSION

Most of the sediment borne by normal streams consists of rock fragments which have become loosened in advance by weathering, or of soil particles. Its load is a ready made one. It is easy to see how running water may pick up soil particles at the very sources of the streams, in cultivated fields, and from any point where the flow is fast enough to enable it to gather them.

While most of the sediment is of this character, rivers often wear away rock which is not weathered. Indeed many of the principal valleys of the earth have been cut in solid rock by river action and often in very hard rock. Such narrow gorges as Ausable Chasm, the Winooski at Bolton and at Colchester, the Otter Creek at Weybridge, the Black river at Cavendish, the Ottaquechee and other places in the various sections of the State, not to speak of such tremendous gorges as the Yellowstone, the Grand Canon and the Royal Gorge, are evidences of the rock-cutting power of moving water. Deep and narrow rock cuttings are done usually by steep, rapid streams, while the processes of valley widening are slower. Swift streams naturally do not meander, but by their constant impact cut and carve their way through the rock.

A stream flowing over a rock bed wears it variously depending upon the character of the rock, the load carried by the stream and its speed. A stratified, thin layered, jointed or tilted rock is easily cut. If smooth the effect is less than if the surface is rough. Much depends on whether the tools (sediment) are or are not at hand. The Niagara rapids do not do serious erosion work in the bed of the stream because the rock is covered with algae. If the stream carried a burden of sand this would be cut.

Chamberlain and Salisbury[1] give a very clear exposition of the way in which the river uses its load in the matter of the excavation of valleys and the making of soils.

"We have next to inquire the methods by which running water uses its tools in the excavation of valleys. When gravel is rolled along in the channel of a stream there is friction between it and the bed over which it moves. If the pebbles be as hard as the bed over which they are rolled their movement must result in its wear, and even if they be softer more or less wear takes place. As the moving stones wear the rock of the stream's bed they are themselves worn by impact with it and with one another. In all cases the softer material suffers the more rapid wear. The first effect of wear on materials in transportation is the reduction of their rugosities of surface. The projecting points and sharp angles are worn off, and the stones are reduced to rounded waterworn forms. The particles broken off make grains of sand, or, if very fine, particles of silt or mud. Even after a stone has been rounded it is subject to further wear and reduction, and in the course of time may be literally worn out.

The sediment carried in suspension, as well as that rolled along the bottom may wear the rock bed of a stream. When a grain of sand in suspension escapes from an upward current it may not sink quietly. If it be caught by a downward current it may be made to strike a blow on the bed of the stream, and the effect of the blow is to wear the surface which receives it. The larger the grain and the stronger the current the greater the wear.

The ceaseless repetition of the blows struck by the material in suspension, or rolled on its bottom, hour after hour, day after day, and year after year, will accomplish sensible results. In the long course of the ages this process has excavated deep valleys. Concomitent processes are largely concerned in making valleys wide, but the depth of valleys cut in solid rock is chiefly the result of the impact and friction of the sediment in transportation.

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[1] Geology Vol. I, pp. 114-16 (1904).

The wear effected in this way is not proportional to the number of blows struck. Since every pebble and every grain of sand carried diminishes the velocity of a stream, and since with diminished velocity the force of the blows struck is diminished, it follows that the blows may become so weak, as the result of their multiplication, as to be ineffective. The larger the load, therefore, which the stream carries, the more the tools with which it has to work, but the less effectively can it use them; and the load may be so far increased as to destroy its corrasive power altogether. On the other hand, the smaller the load of the stream the greater its velocity and the more effectively will its tools be used; but their number may be so far reduced that their aggregate effect is slight. To accomplish the greatest results on a bed of solid rock a stream must have tools to work with, but must not be so heavily burdened as to interfere with its effective use of them.

Whatever the cause of their unequal velocities swift and slow streams corrade their valley differently. The erosion of a swift stream is chiefly at the bottom of its channel. The sluggish stream lowers its channel less rapidly, while lateral erosion is relatively more important. The result is that slow streams increase the width of their valleys more than the depth, while swift streams increase the depth more than the width. It follows that slow streams develop flats, while swift ones do not. Not only is a slow stream more likely to meander; but it is more likely to take advantage of opportunities in this line, for a slow stream gets out of the way for such obstacles as it may encounter, while a swift stream is much more likely to get obstacles out of its way."

The greater the slope the greater the erosion in the stream bed since high declivities greatly increase the transporting power of running water.

Erosion in general, and corrasion in particular are affected by:

(*a*) The character, physical construction, and chemical composition of the rock.

(*b*) The climate.

(*c*) The uneven hardness of rocks.

(*d*) Joints in the rock.

(*a*) *Rock character.* Physical construction. Rocks made up of cemented fragments, like pudding stone and sandstone, or shales, may be either firmly or loosely bound. The less the coherence, the more readily they disintegrate. The finer the particles, the easier they are borne away. If angular they are on that account the better graving tools and the rocks down stream suffer.

Chemical composition. The more soluble the rock, the larger the proportion thus worn away. It does not always follow, however, that the most soluble rock will be the most rapidly eroded. The process of corrasion covers both abrasion and solution; and a soluble rock like a limestone may be less abradable than for example a sandstone, which is cemented with carbonate of lime. In such a case a comparatively small solvent effect would set free a large amount of abraded material.

(*b*) *Climate.* The effect of temperature has already been discussed. Warm moist climates favor erosion. Where temperatures are relatively high and water abounds, vegetation is profuse and the rock structure decomposes to greater depths than in high latitudes, largely on account of the organic acids and other compounds resulting from the decay of vegetation. When water is frozen corrasion and transportation are at a minimum. Humidity tends to favor oxidation, hydration, carbonation, destruction, and as a result vegetation.

The rainfall is the most important single factor in determining the rate and the character of this phase of erosion.

Its amount, kind and distribution determine its effectiveness. Its uniform distribution tends to favor evaporation which naturally tends to lessen erosion, whereas the alternation of wet and dry seasons tends to promote erosion. Some most striking pieces of topography are developed where the rainfall is unequally distributed as to time; where it is too slight or too infrequent for crop growth; and where rocks are slightly but unequally resistant. This is well illustrated in the bad lands of the west. Snowfalls as such have no effect, but the melting snow passing off in freshets has great effect.

The erosive effect of wind in arid regions has already been discussed (pages 206-208). In humid lands it modifies the rate of evaporation and rainfall distribution, raises dust and sand and is thus indirectly effective. The erosion of arid lands is in many ways different from that of humid regions. Valleys develop more slowly; water streams are fewer and less permanent; and an angular topography is more common since there is less rapid decay and less vegetation, the more resistant rock beds becoming very prominent.

Vegetation favors chemical erosion, inasmuch as its decay supplies carbon di-oxid while the solvent power of the roots is also a factor. It tends to retard mechanical erosion, however, being a binder of soil particles.

(*c*) *Uneven hardness of rock.* Rocks of uneven hardness naturally erode differently. The varying shapes of waterfalls may thus be explained. Such ordinarily occur where rivers pass from a more to a less resistant rock.

(*d*) *Joints in rocks* let in water, roots, etc., which help to disrupt them. The effects of joints on erosion are to be seen in rock gorges. Streams sometimes split off an island thus, as for example, in the Winooski gorge.

D. DEPOSITION

All rivers carry more or less mud, sand, gravel, etc. Their work tends to degrade the land to the sea level. They do not carry sediment as a rule directly to the sea but often drop it for a time en route, perhaps to be picked up again when conditions favor. Five things are to be considered in this connection.

(*a*) Why do rivers drops their loads?

(*b*) Where do they drop them?

(*c*) What topographical changes result?

(*d*) What effect is produced on the stream?

(*e*) What does mankind gain or lose?

(*a*) *Causes of deposition.* Running water usually drops its load because of the retardation of its flow. Now its velocity is dependent primarily upon the slope and volume of the stream, and secondarily upon its load and upon the contour of the channel. The steeper the gradient, the greater the volume of the flow. The less the load, and the smoother and narrower the channel, the greater the depth but the less the deposition. The opposite conditions of course favor deposition rathan than removal. The usual cause of loss of speed is a lowered gradient or indeed its drop to an absolutely dead level. Again a stream may broaden its channel without changing the volume of the flow. In arid regions it may be due to the lessened volume caused by evaporation, seepage, or irrigation; and in humid lands, to the subsidence of a freshet flow or to the breaking up into several streams. Again a tributary stream may bring into the main stream more load than it can carry which causes deposition frequently in the form of a delta or bar. A river drops its load as it flows into the sea mainly because the salines cause the fine clay and silt particles to gather into floccules of large size which, being relatively heavy, sink.

(*b*) *Location of deposition.* The loads are usually dropped at points where the water-flow is checked or stopped, as at the base of steep slopes, in valley bottoms, or at the mouths of streams, making in one case alluvial flats, in another alluvial plains, and in yet another deltas. Plains become such as the result of the deposition of sediment over long distances, along valley bottoms, in stream channels, and over the banks making flood plains of alluvium. Natural levees are built in flood time by the mechanical depositions which then occur. Streams in such plains tend to meander and to form ox bows.

When a stream flows into the ocean or a lake, the current is checked and stopped. Its load is dropped and, if not washed away, it forms a delta. Once started below the water line deposition takes place until the delta is raised well above the water level, unless it happen that waves, currents, tidal effects, the sinking of the coast line, etc., prevent the delta from reaching the surface. Deltas are most apt to form in bays, gulfs, etc., which are relatively sheltered from tide and wave. Much of the arable land of the world is actually of delta origin. According as one looks at it, the head of the delta of the Mississippi is located at Baton Rouge, La., or at Cairo, Ill. The general effect of delta formation is to increase land areas and to lower the height of land masses. The delta is not wholly the child of the stream. It furnishes the material, but the lake or sea helps deposit it. The Mississippi delta is advancing at the rate of about 100 yards a year into the gulf. Its length is more than 200 miles, its area more than twelve thousand square miles, and its depth at New Orleans is said to be from seven hundred to one thousand feet. Yet more remarkable deltas are found at the mouths of the Ganges, the Hoangho and other streams.

Changes are often brought about in the contour of the river banks and river bottom through the deposition of eroded material. A barrier of any kind, an upward slope in the river bottom, a projecting point, a lessening gradient; all these serve to check the flow and to cause deposition, to form bars, spits, small islands, to start the stream meandering and forming ox-bows. Peter is often robbed for Paul's benefit when the river bank is undercut and the ox-bow on the other side built in. This work is seen wherever silt laden rivers flow through level valleys. Such valleys have been formed in by-gone ages by such deposition, and as a result the very location of the river channel is frequently changed. The Mississippi in its middle course has often changed its main channel from one location to another.

(*c*) *The topographical changes which* result from deposition are more particularly the formation of flood plains, of levees, and of deltas, and in general the lowering and broadening of land areas.

(*d*) *The effect of deposition upon the stream* is to tend to split it up, to cause it to branch, and in general to become more shallow and less navigable.

(*e*) *The effect upon mankind* of stream deposition has been both good and ill. It has been ill in that not infrequently it has had relation to river floods. The most distressing floods commonly occur in wide valleys where the flats have settled and where a relatively small rise may overflow large areas. Thus the Mississippi bottom lands would be uninhabitable were it not for the extensive and costly system of levees; and a crevasse means dire destruction. The geography of the writer's boyhood days showed the Hoangho debouching at a point three hundred miles away from that where it now enters the sea, a change caused by silt deposition, the undermining and erosion of the soil. The terrible floods of this river have given it the name of "China's sorrow." On the other hand alluvial plains, built up as they are largely as a result of the work of running water, are extremely fertile. The frequent re-deposition of silt and mud serve continually to fertilize and to renew them. Their crop producing abilities are well known. Mankind owes much to erosion and deposition, much of good as well as of ill.

OCEAN WATER IN MOTION

The sea waves of course only touch the land at its margin. They there do a good deal of abrasive work but it is commonly exerted upon beach sands and rocks. The limited extent of these beaches and their non-agricultural character makes their effect relatively unimportant economically, though considerable actually, as may be seen by the sculpture of New England's rock bound coast. Shaler cites an experiment wherein twenty-pound granite paving stones, exposed to Cape Ann's surf for one year, were worn to spheres with an average loss of an inch in periphery.

4. ICE

The northern portions of both continents, roughly down to about 40 to 45 degrees latitude, were covered in prehistoric times by a tremendous ice cap. It had its origin in the western hemisphere at points to the west and to the east of what is now called Hudson's Bay. From these regions as foci this great ice cap, covering all of the northern part of North America, swept slowly down over hill and dale, over mountain and valley alike, covering them all in many cases to a great depth. Inasmuch as all New England was thus buried, and inasmuch as its work profoundly affected and modified New England's topography and soil conditions, it is important that the nature and work of this prehistoric glacier be fairly well understood.

As a result of its grinding and of the deposition of its loads of soil and rock, so-called glacial soils abound in New England. Many of these soils to-day are often in just about the same condition as when the glacier left them; while others have been greatly modified by subsequent geological events. In its pristine purity a glacial soil, the "till" as it is called, is a heterogeneous mixture of clay, sand, gravel, pebbles, an unstratified residue. The pebbles are not rounded as are waterworn stones, but have subangular corners. Their faces are frequently planed and bevelled and they show characteristic scratches. Many loose boulders occur which differ in their mineralogical character from that of the country rock. These are sometimes many tons in weight. They have been brought from points further north by glacial action and are called "erratics." No soils or deposits like these are found in the southern states, but they are common all over the North.

Changes produced by glacial action. In somewhat the same fashion as do the rivers today, this great prehistoric glacier abraded valleys, picked up clay, sand, pebbles, stones, carried them forward, wore and ground them, scratched and scarified the surface over which it passed, and finally, here and there at the edge of the ice stream or where it finally melted, dropped them. In other words it eroded, transported, and deposited as do the modern rivers; although not in exactly the same way.

Glaciers are not extinct agencies but are active to-day. Precisely the same sort of work which covered New England with rock debris and ground its soil proceeds on a smaller scale in mountain regions, such as the Alps and the Selkirks, as well as in Alaska, Greenland, the Antarctic, and elsewhere. The ice masses are moving slowly forward, picking up and dropping their burdens. The frozen streams flow onward and the surface rock between the upper and nether millstones of the glacier and the mountain is ground to flour. The Europeon river Rhone which is of glacial birth may be traced several miles out into the Mediterranean by its white color which is caused by the fine rock flour. The writer has seen the water emerge white as milk from the base of the great glacier of the Selkirks in British Columbia.

The great glacier of prehistoric times, the continental glacier as it is commonly called, modified the surface topography over which it passed more particularly because of:

A. The erosion caused by the ice.

B. The deposition of its load, the so-called "drift."

A. ICE EROSION

The changes wrought by erosion are seen upon the elevations, in the valleys, and in the rock basins.

Elevations. The ancient ice passed over the hills and the lower mountains of the glaciated area, wore off and rounded their tops, and reduced the angular points which stood above the general surface, thus tending to make the surface less rough. One has but to compare the rounded contours of the Green Mountains with the serrated and rugged peaks of the Rockies at once to observe the difference. Vermont's vendure clad slopes are rounded and Colorado's bare peaks are angular, because the former have been subjected to the planing influence of ice whereas the latter have not.

Valleys. The ice deepened the valleys through which it moved, more in many cases than it lowered the hills. Near the coast line it gouged valleys, in some cases forming fiords. This effect is best seen in this vicinity in the irregular coastline of the state of Maine. To glacial action is largely due Vermont's uneven topography, her hills and her valleys.

Rock basins. The ice frequently gouged out hollows where the underlying rock was weak, thus making basins in which the water gathered from the melting glacier, and formed ponds. Most of the myriad lakes which dot northern New England are of glacial origin.

How is a glacier formed? How are its erosive activities accomplished? Glacial ice is ordinarily formed from snow accumulations. These of course are apt to lie on uneven surfaces covered with more or less rock debris. These loose pieces, large and small, become covered, enclosed and embedded by and within the lower layers of the accumulated mass. When in the course of time this snow mass transformed into ice starts on its onward movement or flow, such rock fragments and soil particles as are firmly grasped by the enveloping ice are torn away from the rock masses and borne onwards. Thus the glacier at the outset usually starts with a load. Such of the rock as successfully resists the wrenching effect of the ice, either as it starts onwards or as it moves on its way, is worn down by its passage and by that of the rock debris moving over it, in very much the same way that sandpaper smooths surfaces. Again as the glacier passes over the soil surfaces, the ice freezing to the soil, or, rather, the ice in the soil becoming continuous with that in the glacier, more or less of the soil itself is picked up and carried onwards.

The effects of the glacier are to remove loose debris from the surface and to wear off or break away projecting points. It acts much as if it were a flexible rasp fitting into the surface irregularities of the country. A clean ice moving over a smooth, solid rock erodes but little; but a rock-shod ice wears away any and all surfaces. Once in motion the ice not only carries away debris originally gathered, but accumulates new loads through its rasping and rending processes.

The extent of its erosion is affected by the surface topography, by the amount and kind of loose debris upon its surface, by the resistance of the rock over which it passes, by the thickness of the ice and its rate of movement. A coarse, hard, angular debris is naturally more effective as an abrader than is a fine, soft, rounded material, just as a sandpaper is more effective than would be one clad with clay. Wherever the ice moves rapidly, or is thick enough to cause heavy pressure, or is loaded with a hard rock material and passes over a somewhat soft formation, very effective erosive work is done.

The continental glacier moved over hills and valleys. The highest mountains did not seriously impede its onward course, but were over-ridden, worn down and smoothed off. Valleys were widened, deepened, smoothed. V-shaped valleys were made U-shaped. The bed rock was scratched and grooves developed; the former by stones fixed in the bottom of the glacier; the latter by the action of boulders similarly held in the ice bottom and acting as immense graving tools. The fine clay debris imbedded in the glacier served to polish the rock. These scratches, grooves, and polishings are the handwritings, the autographs of the glacier. The materials thus transported and shaped by the ice were of all grades of coarseness; boulders, pebbles, gravel, fine sand, silt, clay.

How many of our present years elapsed during this great journey of the rock and soil material of the north to New England cannot be told. One may be sure, however, that the time was long and the movement slow. Likewise, that a very considerable share of New England's arable soil is derived from rocks of Canadian origin is also certain.

B. DEPOSITION OF THE "DRIFT"

The changes wrought by the deposition of the drift are seen all over New England. A glacier in motion drops debris beneath its own structure and against the hills and rocks on either side. It may, like the river flow, become overburdened and drop some of its load, later to pick it up again. The deposits may, therefore, be either permanent or temporary. Deposition is particularly active at the sides and end of the glacier. It goes on faster here than elsewhere, mainly because of rapid melting, thinning, and weakening. Hence the thickest deposits of drift are apt to be found at the ends and at the margin. These accumulations are called moraines, either terminal or lateral according to location. The terminal moraine of the prehistoric glacier stretches across the continent from a point on the Atlantic coast somewhat south of New York, roughly along the lines of the Ohio and Missouri rivers, passing out of the confines of the United States in Washington. Such well known pieces of New England topography as Bunker Hill, Dorchester Heights—whence Washington drove the British from Boston,—the various islands in Boston harbor, Nantucket, Martha's Vineyard, and Long Island, New York, are glacial deposits largely of the morainal type.

Sooner or later, since of course all of the continental glacier melted ages ago, all the material picked up by the ice was deposited. Had this drift deposit been made equally thick everywhere its general effect would have been simply to have elevated those surfaces upon which it was dropped without effect upon the topography. But as a matter of fact it was laid down very unevenly and hence the topography has been profoundly modified. Usually more of this drift material was left in the low places than in the high ones, so its general tendency was to level the surfaces over which the glacier passed, although the surface was often left more rough than it was originally. As already remarked, the drift frequently filled valleys at some points and not at others, making dams, causing the accumulation of water and producing small lakes. Some of these had but a temporary existence, but many of them, such as the Great Lakes, and those which dot the northern North Central States, New York and New England, have remained to this day.

Glacial deposits are distinctive. Moving ice does not assort and stratify deposits as does running water. Boulders, cobbles, pebbles, sand, clay, are more or less confusedly intermingled. The lack of stratification, as well as the uneven deposition and distribution of the material, the scratches upon the stones and the very fine rock flour which is the result of grinding and not of decay, are distinctive characteristics. Glacial rock surfaces are smoothed as by abrasion, scratched, and grooved. Lakes, ponds and marshes abound. Surface boulders of great size, unlike the country rock, are common. The low, rounded hills at the terminus and sides of the moraine known as drumlins are also characteristic. Bunker Hill is a drumlin.

The effects of glaciation upon human affairs are striking. The industrial history of the region which the ice covered has been markedly affected thereby. In many locations the soil has been made more abundant and the slopes as a whole reduced. The quality of the soil has in many places been improved, although this has not always been a fact. The principal wheat and hay areas east of the Rocky Mountains in this country and Canada are glaciated areas. This is not saying that if climatic conditions had favored similar crops might not have been grown to advantage on non-glaciated areas. The lessening of gradients has favored road making and facilitated transportation. The impounding of water in lakes and the construction of falls and rapids, both of which are in part or wholly due to glaciation, have enabled much power transmission. The deeper soils have tended, moreover, to absorb more of the rainfall and to favor its more even passage into the country drainage. Divers industries like brick making, cement making, etc., have been favored by glaciation.

On the other hand it may be said that in some places the quality of the soil has been injured. In areas where the drift was notably stony, as is the fact throughout much of New England, a tremendous excess of stones, pebbles, etc., was deposited, making farming operations correspondingly difficult. The reason why considerable areas in many sections of New England are relatively unprofitable for agricultural operations is in part due to the action of the glacier, which perhaps deposited in this region more than its normal share of stones. These, while of no aid in farming operations, have been of immense service in the forming of gravel beds which have made cheap yet good road making a possibility. This has been a factor in the making of New England naturally a manufacturing rather than an agricultural region.

5. LIFE

Both plant and animal life affect rock disintegration and soil formation.

A. PLANT LIFE

(*a*) *Algae, fungi, bacteria* (*Thallophytes*). These are the simplest forms of plant life. Most of them are minute, one-celled organisms; others are many celled and complex, and some of them are relatively large in size. They live under widely varying conditions. Some thrive in polar regions at 32° F. or below; others live only in hot springs at high temperatures; some in salt water, others in brackish, others in fresh water; while some flourish in the utter absence of water. The thermal algae gather and deposit carbonate of lime or silicic acid. Lime securing algae are also abundant in warm and shallow ocean water. To be sure the product of their work largely drops to the deep sea abysses, still they are a factor to some extent in reef making. The red algae also help build coral reefs. The "stoneworts," an algus group living in fresh and blackish waters, likewise secrete carbonate of lime. They are thought to have had relation during past ages with the making of marls and perhaps of some limestones. Diatoms gather silicic acid, immense deposits of their remains being found in many sections. Sea weeds functionate also and gather large amounts of mineral matter and tremendous amounts of organic matter. They are frequently gathered along seacoasts and used for manurial purposes. Fungi work on the organic matter of the soil. Their thread like mycellia spread apart the cellular tissues and their enzyms dissolve, disintegrate, and break it down into humus.

An omnipresent, lowly and familiar form of life is the lichen which grows on the old stone walls, tree trunks, etc. The lichen is really a dual life, a fungus and an algus, living symbiotically, that is to say for their mutual benefit. Its particular function, so far as it relates to the matter now in hand, is the disintegration of the rock or tree structure on which is grows. This apparently is brought about largely by the exudation of an organic acid similar to, if not identical with, oxalic acid.

"These several forms of plant life growing upon the rock ledges, and sending their rootlets into cracks and crevices, aid in their disintegration, though slight be their action. The plants die and others grow upon their ruins, thus accumulating with extreme slowness the thin covering of humus which serves to retain water and thus bring the rock under its influence. They act both as solvents and as de-oxidizing agents, and as time goes on, enable a sufficient amount of soil to gather for other and higher forms of plant life which exert still more disintegrating forces." (Merrill).

It is thought that the work of bacteria is recognizable in the rocks far back in geologic ages. Their remarkable adaptation to varying conditions, their great ability to endure vicissitudes of environment, indicate that they are old and plastic forms of life. Their work was thoroughly discussed in bulletin 130, which, although in small numbers, is still to some extent available; hence no further reference will be made to it here. They are, moreover more effective in modifying soils than in the disintegration of the rocks.

(*b*) *Mosses* (*Bryophytes*). Certain mosses, especially the sphagnum moss, are important factors in the formation of peat. Their bog growing habits and their peculiar trait of continuing to grow above while dying below fit them admirably to this purpose.

(*c*) *Ferns, horsetails, lycopods* (*Pteridophytes*). From these lower forms of plant life were derived coal, natural gas, petroleum, etc.; but they are not thought to have contributed to soil making save in so far as fuel combustion furnishes carbon di-oxid to the air.

(*d*) *Seed-bearing plants in general* (*Spermatophytes*). These plants came late in geologic life. Their important service of course has been as food to the higher land animals. The higher mammals only arrived after the seed bearing plants became the dominant type of vegetation. Their relationship to animal life, to the humus content of the soil, to manurial supplies, etc., is so obvious as to need no discussion. Their particular and important work outside of food and humus furnishment pertains more particularly to their physical and mechanical effects, to root penetration and solution, and to their decay induced by fungi, bacteria, etc.

Vegetation, aside from incidentally shaping the surface of the soil, conserving water, and making it more effective, aids in rock disintegration and soil formation by the penetrating power of the roots, by the solvent power of root exudates, and through the effects caused by decaying organisms.

The power of the growing root to penetrate and to break rock structure almost passes belief. The upheaval of sidewalks, the breaking of rocks and boulders by growing tree trunks, are examples of this power. The writer remembers seeing over thirty years ago during his college days a model of a Hubbard squash which a few years before had raised by the expanding power of its growth a weight approximating three tons. On a smaller scale this penetrating effect of the rootlets serves to loosen soil particles, to open cracks, and thus to enable the entrance of water, entailing then all the various effects already discussed. Moveover, wherever the small rootlets force their way and then decay, water and air may later penetrate. The depth to which these rootlets may grow varies of course with the nature of the soil and plant, but some roots in some soils have been found to ramble more than fifty feet.

Root solution. Many, if not all, roots exude acid fluids which seem to possess solvent powers. A classic experiment in plant growth is to permit the rootlets of a young corn plant to grow along side of a polished marble slab, which after a few months is dug up and found to be etched with the tracery of the roots.

Humus. The relationship of these plant organisms to the formation of humus was so extensively discussed in bulletin 135, which is still available on application, that this phase of the matter need not be considered here.

B. ANIMAL LIFE

Animal life is dependent for existence upon the decomposition of mineral matter by the higher plants and upon its absorption within plant tissues. Animals cannot live directly upon mineral matter, but do live upon the soil indirectly through the agency of plants. Animals are analyzers rather than synthesizers. They are dynamic rather than constructive agencies. Yet they transform vegetable organic matter into animal organic matter, which is a decided advance in organization.

The eight principal groups of animal life have each contributed to soil formation or modification. For our purpose they may be considered in seven groups, three being united into one since, as their functions, so far as they relate to the matter in hand are similar, while one—the vertebrates—is split into two.

(*a*) *Protozoa.* These are usually one celled organisms. Rhizopods, infusioria, foraminifera, are the names of important kinds. Some gather carbonate of lime, some silicic acid. Some contribute to the deep sea oozes; others to the chalk deposits; others to the multitudinous limestone and silicious silts. In prodigious numbers, utterly beyond the possibility of man to conceive or of mathematics to enumerate, they have lived and are living in the sea. The rain of their shells to the bottom of the ocean is said to raise it about 800 feet in one hundred thousand years. The ocean bottom is thus built up about as rapidly as chemical denudation reduces the height of the land. Nature's effort in this way tend to reduce to a common level.

(*b*) *Corals and sponges* (*Coelentera*). The sponges play a minor part, the corals a major part in soil making. Corals are small animals, not insects as is commonly thought, living near the sea surface, which attach themselves to the limestone skeletons of their ancestors and build upwards towards the surface. They do not grow in cold waters or in great depths. Their activities are limited, therefore, to tropical waters, and to the building of reefs in shallow waters or on the submerged shoulders of mountain peaks, thus forming atolls or coral islands. If, however, one was to gather together in a single land mass all the coral islands of the seas, it would make a very respectable fraction surface of the earth.

(*c*) *Mollusks i. e., oysters, clams, etc.* (*Echinodermata Molluscoidea, Mollusca.*) The essential function of these types —so far as it relates to soil making—is the secretion of carbonate of lime. Oyster shells, clam shells, etc., are used in some sections for road making and occasionally ground for use as soil amendment. Several of the limestones of ancient origin appear to be related to these forms of life.

(*d*) *Earthworms* (*Vermes*). None of the forms of animal life thus far mentioned begin to have the importance in this connection that is possessed by the earthworm, the common angleworm. It remained for Darwin in his famous publication on "The Formation of Vegetable Mould" to develop the fact that the service of the earthworm to mankind in the matter of soil making is of fundamental importance. They burrow in the surface soil and derive their sustenance from the organic matter it contains. In order to obtain this organic matter, however, they swallow the soil quite without selective action and pass it through their alimentary canals, rejecting the non-nutritious portions which are nearly equivalent in bulk to those first taken in. Darwin states that worms may bring to the surface yearly as excreta more than ten tons per acre of fine dry mold and that the "whole superficial bed of vegetable mold passes through their bodies in the course of every few years." He estimates the rate of accumulation to be an inch in five years.

Worms also bring about some slight admixture of organic matter throughout the soil by their habit of coming to the surface nightly and dragging downward small bits of leaves, grass, etc. The numbers were estimated by Darwin to have been nearly fifty-five thousand per acre of garden soil and about half that number in pasture land. The earthworms are great soil modifiers, stone buriers, hollow fillers, adding to the availability of the organic matter of the soil, important factors in its humification.

(*e*) *Ants, beetles, etc.* (*Arthropoda*) Many of these animals are of no particular service save as they rearrange soil particles and increase porosity. This tends to promote the admission of air and of water to lower soil levels and to favor chemical and physical changes. The work of ants is usually limited to relatively dry and light soils. What they do there is in a way comparable with what is done by earthworms in more moist soils. Shaler calculates that in a certain field in Cambridge, Mass., the ants have transferred soil matter from lower levels to the surface in amounts sufficient to form an annual layer of a fifth of an inch. He further says that where the larger ant hills are numerous as they are in certain sections, these insects bury much vegetable waste thus conveying organic matter into the earth, which serves them as food. These organic wastes are important factors in soil enrichment.

Much stress is laid upon the work of ants in the bringing about of soil changes and rock decomposition in the tropics. Indeed it is almost beyond belief. Their numbers are legion. They are omnipresent and active 365 days annually. They live in great colonies, excavate tunnels hundreds, even thousands, of feet long which branch in every direction. Their mounds sometimes contain several tons of earth. They are leaf eaters and strip the forests at times with great rapidity and thus make much humus. The great amounts of carbonic acid gas arising from their breath and from the decomposition of their excreta and their dead bodies tend markedly to increase the availability of the soil constituents. In temperate regions the ant is looked upon as a nuisance; and viewed from every standpoint other than that occupied in this article they are a nuisance in the tropics; but they are notwithstanding of considerable importance in soil formation.

(*f*) *Vertebrates.* The various classes of brute creation of the vertebrate types, fish, reptiles, birds and mammals, have all had to do with soil making or soil improvement; the three former more particularly through their direct or indirect contributions to guano deposits. Among the mammals which have had something to do with this matter might be cited the woodchuck, the prairie dog, and others. These exert a decided though local influence in admixing the lower with the upper portion of the soil, thus permitting a more ready passage of water to the lower levels and facilitating oxidation and decomposition. Of course it is well understood that these animals do more harm than they do good, but they are a factor in the matter of the making of soil.

(*g*) *Man's* agency in this general matter should not be overlooked. He is an animal as much as is a woodchuck, an earthworm or a diatom. It is greatly to be deplored, however, that his relationship to the matter of soil making has been more destructive than constructive, through prodigality, thoughtlessness, and disregard of the future. He has hurt more soil than he has helped. The pioneer methods of farming have been destructive rather than constructive: have used up rather than built up the soil. This matter, however, was thoroughly discussed in last year's bulletin 135, pages 148-150, and need not be further considered here.

SUMMARY

A soil as viewed by the physiographer is a loosely coherent, disintegrated residue of mineral and organic matters. Soil is born of rock, being formed therefrom through the activities of divers forces, some from within (volcanoes, earthquakes, rock changes); and some from without (the air, the soil water, water in motion, ice action, plant and animal life). Pages 199-202.

The internal forces were more active in the earlier days of the world's history than they are today. Volcanic rock readily disintegrates to form soil. Crustal movements have elevated mountain chains and sunk continents. Changes in rock structure have led to increased readiness of disintegration. Pages 203-204.

The external forces have been and are the great soil makers.

The air chemically aids in weathering through its oxygen and carbonic acid gas contents, particularly when these are absorbed by water. It mechanically erodes rock by wind driven sand and builds up vast areas of dust soils. It affords opportunity for heat and cold to expand and contract rock particles, leading thus to their disruption, particularly through freezing water which, in expanding, bursts rocks asunder. Pages 205-209.

The ground water acts chemically to oxidize or rust, thus causing crumbling; to de-oxidize especially in swampy areas; to hydrate and thus to burst; and to dissolve rocks, particularly limestone, gypsum, etc. Mechanically it causes creeps and slides. Hot springs dissolve silicious and calcareous rocks. Pages 209-215.

Weathering, a general term covering the effect of the air and ground water and of life activities, is an important process, the essential function of which is to loosen rock particles as a precedent to their removal by wind or water. The thickness of the soil blanket thus formed varies from nil to a great depth but rarely exceeds a hundred feet. Pages 214-215.

Water in motion is the great transformer of nature. Erosion, its great function in soil making, consists of three subprocesses; weathering, defined above; transportation, the removal of loosened or dissolved fragments to other points by wind or water; and corrasion, the wearing effect upon the river bed produced by solution or by the frictional impact of the weathered fragments in transit. The amount of material thus weathered, worn away and moved is stupendous. Erosion may be constructive, if exerted on rock to make soil; or destructive, if exerted on soil to remove it from one point to another or to the sea. Sundry factors influence erosion, more particularly the character of the rock and its hardness, and climatic conditions. The deposition of weathered and corroded material is an important matter in connection with the building up of alluvial soils. Sundry causes bring about this deposition, more particularly the retardation of the river flow. It usually occurs in valley bottoms and at the mouths of streams. The topography of the country round about and the nature of the stream are affected thereby; and mankind's welfare is bound up therein. Pages 216-229.

The continental glacier of prehistoric times swept over New England, abrading, eroding, depositing clay, sand, pebbles, stones; rounding the mountain tops and deepening the valleys; hollowing out rock basins for ponds and lakes; profoundly modifying the character of its soil and to a large degree determining its industrial character as a manufacturing rather than an agricultural section. Its handwritings are seen in every direction; and perhaps as much as or more than any other one factor it has determined the character of northern agriculture. Pages 230-236.

Plant and animal life activities are important agencies. Lichens tend to disintegrate rock structure; sundry minute forms of both plants and animal secrete carbonate of lime or silicic acid. They tend also to disrupt and disintegrate rocks by their exudations. Sphagnum moss forms peat beds. Seed bearing plants feed animal life and through decay furnish humus. Their roots by their penetrating powers tend to open up the soil and to break rocks and by their solvent powers to dissolve minerals. Several forms of animal life functionate. Corals build reefs; mollusks form limestones; earthworms aid in the formation of vegetable mold and the increase of the soil humus; ants, particularly in tropical countries and in drier soils, act similarly; major animal life is less important in this connection; and, unfortunately man's efforts as a rule have been destructive rather than constructive. Pages 236-242.

ARTICLES AND WORKS DEALING WITH SOIL PHYSIOGRAPHY

The only publications dealing specifically with the matter of soil physiography which have come to the notice of the writer or which were found by a somewhat cursory survey of indices of governmental and station publications, are given below. This list does not include:

1. The sundry soil survey articles of the Bureau of Soils of the United States Department of Agriculture, each of which naturally reviews local physiography.
2. The many bulletins, professional papers and monographs of the United States Geological Survey dealing with the geology or the economic geology of a given region or discussing the geological reconnaissance of a stated section. These also, and naturally, review local physiography.
3. The several water supply and irrigation bulletins of the United States Geological Survey, many of which incidentally discuss these general matters.
4. The reports of the several state geological surveys, many of which contain articles incidentally or to a considerable extent dealing with soil origin.
5. The many excellent physiographys issued as text books or the chapters in text books on soils dealing with its origin.
6. Articles in scientific journals.

The list is not meant to be in any way a complete bibliography but is simply a list of books and monographs having more or less relation to the matter in hand with which the writer is acquainted and which have been consulted in the preparation of the matter on which this article is based.

Merrill. Rocks, Rock Weathering and Soils, Parts III-V (1906).

Chamberlain and Salisbury. Geology, Vol. I, Processes and their Results, Chaps. 2-5, 9-11 (1906).

Salisbury. Physiography (unabridged), Chaps. 2-9 (1907).

Clarke. The Data of Geo-Chemistry, U. S. Geol. Sur., Bul. 330, Chaps., 2, 3, 12 (1908).

Whitney. Soils of the United States, U. S. Dept. Agr., Bu. Soil, Bul. 50, Part I (1909).

Shaler. The Origin and Nature of Soils, U. S. Geol. Sur., Rpt. 12, pp. 219-348 (1898).

Dale. Taconic[1] Physiography, U. S. Geol. Sur., Bul. 272 (1905).

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[1] Western Rutland and Bennington Counties.

Perkins. Geology of Grand Isle County, Vt. State Geol. Rpt. 3, pp. 102-173 (1902), 4, pp. 103-143 (1904).

Russell. Rivers of North America (1898).

Wright. Ice Age in North America (1890).

Darwin. The Formation of Vegetable Mold through the action of Worms (1883).

Salisbury. Physical Geography of New Jersey, N. J. Geol. Sur., Vol. 4 (1895).

Clark and Mathews et al. The Physical Features of Maryland, Md. Geol. Sur., Vol. 6, (1906).

Hitchcock. Champlain Deposits of Northern Vermont, Vt. State Geol. Rpt. 5, pp. 236-253 (1906).

Hitchcock. Geology of the Hanover Quadrangle, Vt. State Geol. Rpt. 6, pp. 139-186 (1908).

Tarr. Geological History of the Chatauqua Grape Belt, New York (Cornell) Sta. Bul. 109 (1896).

Spencer. Origin of Soils Geologically considered, Ga. Sta. Bul. 2, pp. 27-31 (1888).

Knight. Geology of the Wyoming Experiment Farm, Wyo. Sta. Bul. 14, pp. 103-117 (1893).

Whitney. Relation of Geology to Agriculture, Md. Sta. Rpt. 4, pp. 261-264 (1891).

GLOSSARY

Extensive glossaries were printed in bulletins 99, (1903) and 130, (1907) it being thought that they might prove helpful to their readers. The matter in this issue pertaining to soil physiography is inevitably so technical that it seems likely that another glossary may prove useful to the particular class of readers to which this bulletin appeals. No attempt is made to define any term which is not a technical one, save such as are in common usage but bear a technical meaning as employed in this connection. However, the term "technical" is construed liberally and many definitions are included which doubtless are unnecessary. It seems best, however, to err on the side of over-definition than the reverse. The writer has been guided to a large extent in the formulation of definitions by the 1906 edition of the Standard Dictionary.

The words in the definitions which are *italicized* are themselves defined in the glossary, enabling thus the clarification of a possibly obscure definition by cross reference. The definitions are in the main restricted to the usage of the terms in physiography. Exactness of scientific terminology has not been sought, the attempt being rather to make more clear the statements in the main body of the article than to afford complete and comprehensive definitions. No attempt is made to define words having to do with fertilization or with the fertilizer trade, or that are to be found in articles in this bulletin other than that on soil physiography. The glossary in bulletin 99 (which is available to any reader who desires it) is thought sufficiently to cover these terms.

In the language of the market, "if you do not see what you want, ask for it." If you fail to grasp the meaning of a word, a phrase or a proposition; if any matter in this bulletin is not clear; or if you wish advice touching any phase of fertilization, soil management, or of agriculture in general, write to the Experiment Station, Burlington, Vt., and answers will be cheerfully returned without charge.

ABRASION.—Rubbing or wearing away; as the abrasion of rocks or earth by *glacial* action.

ALGAE.—Small, green plants usually of microscopic dimensions living mostly in fresh water. The green scum on stagnant water is usually made up of algae. *Seaweed* are large algae.

ALKALINE CARBONATES.—A general term for sodium and potassium carbonates, more particularly the former.

ALKALINE SULPHATES.—A general term for sodium and potassium sulphates, more particularly the former.

ALLUVIAL.—Adjective of *alluvium* (which see).

ALLUVIAL FLATS; ALLUVIAL PLAINS.—Broad, level areas mainly composed of silt and clay, formed by water deposition. (See flood plain.)

ALLUVIUM.—A deposit of clay, *silt*, mud, or of the finer particles of sand, formed wherever the flow of a muddy stream is checked. It is found chiefly on *flood plains*, at river bends, at the mouths of streams as *deltas*. A very fertile type of soil.

AMMONIA.—A pungent gas; a combination of *nitrogen* and hydrogen; a product of manurial *decomposition;* an ingredient actually or potentially of most commercial fertilizers. (See bulletin 130.)

AMORPHOUS.—The reverse condition from *crystalline* (which see); structureless, that is to say without special, fixed character. A rock is said to be amorphous when it is not of a *crystalline* character. Slate rock, for instance, is amorphous.

ANALYZER.—An *organism* which tends to break down into relatively simple molecules those which are more complex. For example, an animal is termed an analyzer because through its life processes, particularly those of digestion and excretion, it changes complex bodies like protein, starch, fat, etc., into simple bodies, like urea, *carbon di-oxid*, water, etc. The reverse of *synthesizer*, (which see).

ARID.—Devoid or nearly devoid of rain-fall. The arid and semi-arid section of this country is approximately that west of the one hundredth meridian, exclusive of certain portions of the Pacific coast.

BACTERIA.—Low forms of plant life consisting of single cells of protoplasm, microscopic in size, swarming in the soil, water, and throughout nature. They are important factors in fertilization and in soil formation. (See bulletin 130, page 219.)

BAD LANDS.—Areas where through *erosion*, due partly to the action of wind and partly to that of water, the rock *strata* are deeply cut into fantastic forms. Especially seen in this country in south-western South Dakota.

BIOLOGICAL.—Biology is the study of living matter, plant or animal; the science dealing with the structure, growth, development, distribution and functions of plants and animals, and the causes thereof.

CAPILLARITY.—Capillary movement is that movement of water in soil, usually upwards but sometimes lateral, occurring between soil particles and through soil pores, caused by the attraction or pull of the solid matter of these particles for or on the fluid. The absorption of ink by blotting paper is due to capillary movement of the ink between the fibers of the blotting paper. Oil rises in the lamp wick for a similar reason.

CARBONIC ACID GAS.—(Carbon di-oxid.) A common constituent of the air; used by plant life in building starch and other bodies; a combination of carbon and *oxygen;* the gas of the druggist's "soda water."

CELLULAR TISSUE.—A general term for the substance which makes up most of the cell wall and other fibrous matter in the younger parts of plants. Much of this hardens into wood in the later life of the plant. Cotton fiber is nearly pure cellulose.

CHEMICAL.—Chemistry is the science dealing with the interior composition of compounds, with special kinds of matter, with matter in the atom and *molecule*, as distinct from matter in the mass. The consideration of matter in the mass lies within the domain of *physics.*

CHEMICAL DENUDATION.—The *denudation*, (which see) of rock brought about by *chemical* action and particularly by *solution.*

CHEMICAL EROSION.—See *chemical denudation.*

CONSTRUCTIVE EROSION.—That type of *erosion*, (which see) which serves to construct soil from rock, as distinguished from that type which simply moves soil already formed from one place to another. Constructive erosion tends to increase the total soil content of the world; *destructive erosion* to decrease it. See page 219.

CORRASION.—A subprocess of *erosion*, involving *abrasive* and *solvent* effects. See page 222.

CREVASSE.—An accidental opening in a *levee;* or a deep fissure in the ice of a *glacier.*

CRYSTALLINE.—A rock which is composed of angular grains or particles, each one of which is of essentially the same shape and character as the other. A rock which is composed of rounded or irregular shaped fragments is not apt to be a crystalline rock.

DECOMPOSITION.—The process whereby living or once living tissues are more or less entirely broken down and destroyed. Decomposition pre-supposes a life process, whereas a mineral material is more commonly *disintegrated.* The word decomposition, however, is not infrequently used in connection with the breaking up of rock structure, particularly if this occurs as a result of the action of *chemical agencies* rather than of *mechanical agencies.*

DELTA.—An *alluvial* deposit, commonly formed at the mouth of *silt*-bearing rivers, particularly those which flow into the sea.

DEGRADE (as used in this article).—To reduce the height of any portion of the earth's surface by *erosive* action, as of rivers.

DENUDATION.—The erosion of rock to such an extent that *strata* formerly covered are exposed, or of soil to such an extent that large amounts are removed and deep gullies formed. Denudation may be either *chemical* (which see) or *mechanical* (which see).

DE-OXIDATION.—The removal of *oxygen* from a *molecule.* See page 212.

DEPOSITION.—The process whereby through natural accumulation rock or soil material is laid down by wind or water. The opposite of *denudation*, (which see).

DESTRUCTIVE EROSION.—That type of *erosion* which tends to wear away soil structure already in place and in service; particularly seen in this country in the South. Discussed at length on pages 148 to 150 of bulletin 135.

DIASTROPHISM.—Crustal movements in general, ranging from those causing earthquakes to those which bring about slight and slow movements. The process whereby the earth's crust has become modified and deformed, producing continents, ocean beds, etc. See page 204.

DIATOM.—A plant of microscopic size; a subspecies of *algae*. Its skeleton is *silicious* in character. See page 236.

DISINTEGRATION.—The decay and wasting away of rock structure under the effects of *weathering* and particularly of atmospheric agencies. The term is commonly applied and should be restricted to the *mechanical* changes in rock structure in contradistinction to its *chemical* destruction.

DRAINAGE BASIN.—The area drained by a river and its tributaries.

DRIFT.—An accumulation of clay, sand, gravel, pebbles, and boulders which has been moved by glacial action and deposited at the end or side of the *glacier* or beneath it. Sometimes called glacial drift, glacial deposits, *till*, (all of which see).

DRUMLIN.—A low mound or hill of *glacial* origin composed of *till* (which see).

DUNE.—A hill or ridge of loose, drifting sand formed by wind action, commonly occurring upon seacoasts or lake shores, sometimes passing far inland and overwhelming farms and buildings.

DYNAMIC.—Pertaining to motion resulting from the exhibition of force. Dynamics (noun) has to do with the effects of force in producing motion and the laws of motion thus engendered.

EARTHWORM.—The common angle worm.

ECONOMICS.—The development of material resources is the field of Economics.

ENZYM.—An unorganized or *chemical* ferment of animal or of vegetable origin; e. g. pepsin (from the animal stomach), diastase (starch digester from malted barley), etc. *Bacterial* effects are largely enzymic in their nature, being brought about through the action of the enzyms they secrete.

EROSION.—The wearing away of rock or soil by wind or water. The term covers three subprocesses, *weathering*, *transportation* and *corrasion*, all of which see. See also pages 217-218.

ERRATIC.—A boulder usually of large size *transported* and *deposited* by *glacial* action.

ERUPTIVE ROCK (igneous).—One originating from volcanic action, although not necessarily ejected from a volcanic crater.

EXFOLIATION.—The scaling off of the outer layers of a boulder or of rock structure, particularly under the influence of heat.

FELDSPAR.—The name of a group of minerals or rocks. Granites are composed of *quartz*, feldspar, and, usually, mica.

FIORD.—A long, narrow arm of the sea, usually with steep rocky banks; as for example on the coasts of Alaska, Norway, etc.

FLOCCULE.—A loosely joined aggregation of clay or *silt* particles, gathered together usually by *chemical* or *physical* action. A *silt*-laden stream when reaching the sea water *deposits* its *load* because of the flocculating action of the salts of the sea water upon the *silt* and clay it bears.

FLOOD PLAIN.—A plain which has formed the border of a stream and on which the stream has deposited *silt* when at flood. Ox bows are types of flood plains.

FORAMINFERA.—Minute marine animals.

FUNGI.—A large group of plants of a low order and simple structure such as *molds*, mildews, puffballs, toadstools, etc. They are usually colorless and differ from the *algae* in that they are never bright green. *Bacteria* are sometimes grouped with the fungi. Some are edible, some poisonous, some cause plant or animal disease, some are economically highly important.

GEOLOGICAL.—Geology is the science dealing with the present condition of the structure of the earth, its *physical* forces, its past developmental and structural history, the causes and modes of *physical* changes, etc., and the occurrence and development of life.

GLACIATION.—The work accomplished by *glaciers* (which see).

GLACIER.—A field or stream of ice formed from compacted snow which moves slowly onwards over slopes and through valleys, *eroding* the territory over which it passes. See page 232.

GLACIAL SOIL.—See *till*.

GROUND WATER.—That portion of the rainfall which passes into the soil by *percolation*.

GYPSUM.—Land plaster, sulphate of lime. Mined in central New York, Nova Scotia and elsewhere. Commonly used in stables for the fixation of *nitrogen* as well as upon the soil as an amendment.

HORSE TAIL.—A common plant, sometimes called the scouring rush. Poisonous in hay to horses. See bulletin 95.

HUMIDITY.—Dampness; as the humidity of the atmosphere.

HUMUS.—A black or brownish soil ingredient, the resultant of vegetable decay; vegetable *mold*. Vegetable matter decaying is not humus; vegetable matter decayed is humus. Soil humus is discussed at length in bulletin 135, pages 153-175.

HYDRATION.—The absorption of water into the *chemical* structure of a compound. The absorbing of water by a sponge is not hydration, but the entrance of water into the structure of a *molecule* constitutes hydration.

INFUSORIA.—A form of microscopic animal life. (See diatoms).

INVISIBLE LOAD.—See load.

LATERAL MORAINE.—A *morainal* formation at the side of the *glacier*. See moraine.

LAVA.—Molten rock from volcanoes or the same after solidification.

LEVEE.—An embankment, sometimes natural, sometimes artificial, beside a river or other body of water, which tends to prevent overflow.

LICHEN.—Plant life growing as gray, blackish, brownish or yellow crustlike patches on rocks, tree trunks, soil and elsewhere. They derive their sustenance entirely from the air. They consist of a dual life of *algae* and *fungi*.

LOAD OF STREAMS.—(Invisible) The dissolved solids in flowing water.

LOAD OF STREAMS.—(Visible) The sediment suspended in flowing water, composed of clay, *silt*, etc.

LYCOPOD.—A club moss plant.

MECHANICAL.—Having to do with the phenomena caused by the action of force on material objects.

MECHANICAL EROSION.—Such *erosive* effects of *weathering* as simply modify the size of particles without changing their *chemical* character.

METAMORPHOSIS.—The passing from one form, shape, or character into another.

MINERALOGICAL.—Having to do with minerals either of a metallic or of a rocky nature.

MOLECULE.—The smallest part of a compound substance capable of separate existence without modification of its properties.

MOLLUSK.—A class of animals usually incased in shells such as snails, clams, oysters, and the like.

MORAINE.—The collection of rock and soil debris in ridges or humps at the edge or end of a *glacier*. The moraine is called a *terminal* or *lateral moraine* according to its location.

MOLD.—(Vegetable). A particularly fine, friable, fertile soil, containing much *organic matter*.

MYCELLIA.—Thread-like tubes proceeding from a *fungus*, through which it draws nourishment; comparable in function to the roots of higher plants.

NITRATES.—Combinations of *nitric acid* with bases (lime, potash, soda, etc.)

NITRIC ACID.—An acid composed of hydrogen, *nitrogen* and *oxygen;* the product of nitrification.

NITRITES.—Combinations of *nitrous acid* with bases (lime, potash, soda).

NITROGEN.—A gaseous element, constituting about four-fifths of the air; the central element of flesh structure and of protein.

NITROUS ACID.—A lower oxidation (i. e., containing one less atom of *oxygen*) than *nitric acid;* the result of the second step in the process of *nitrification.* (See bulletin 130, pages 236-244.)

ONE-CELLED.—A living body consisting of but a single cell or unit of life. The very lowest forms of plant and animal life are one-celled.

OOZE.—A slimy deposit of limy matter found on the deep sea bottoms, consisting wholly of the remains of *foraminifera.*

ORGANIC MATTER.—Soil materials derived from life processes, as apart from those of rock origin; material capable on combustion of complete volatilization.

ORGANIC ACID.—An acid derived from *organic matter* living or dead, such as causes the sourness of the apple (malic acid) or of peat (*humus* or other acids).

ORGANISM.—An organized living being, either plant or animal, so called because it is made up of different organs or parts which have certain functions to perform and which are mutually dependent and all essential to life activities.

OUTCROP.—The exposure on the surface of a rock; also the rock thus exposed.

OXIDATION.—The addition of *oxygen* to a metal or compound. Rusted iron is oxidized iron. Rocks containing iron when acted upon by water are quite apt to become oxidized.

OXYGEN.—A colorless, tasteless, odorless gas, constituting by weight a fifth of the air and eight-ninths of water.

OXALIC ACID.—An *organic acid* similar if not identical with that exuded by root action.

PERCOLATION.—The downward passage of rain water through the soil.

PHYSICAL.—Pertaining to the properties and the forces and the phenomena of physical matters, more particularly in its energy relations. Its soil relations have to do particularly with moisture and heat.

PHYSICAL CONSTITUTION OF ROCK.—Having to do with the weight, hardness, form and external characteristics of the rock as apart from its *chemical* composition.

PHYSIOGRAPHY.—Physical geography. A description of nature. That branch of geography which treats of the *physical* features of the earth, more particularly its surface and atmosphere and the form and character taken by that surface under the action of existing *physical* agencies, more especially the distribution and flow of water and of ice, the effect of atmospheric agencies and of the various forms of animal and plant life.

POROSITY.—A property of possessing pores, i. e., minute openings or interstices between particles. A soil, even the most compact possesses more or less pore space.

PRECIPITATION.—Rainfall.

PRE-HISTORIC.—Antedating man's written records.

PROTOZOA.—A main sub-division of the animal kingdom, embracing largely *one-celled organisms* or those of extremely microscopic size.

PUMICE.—A form of *lava* (which see).

QUARTZ.—An extremely hard mineral composed, when pure, solely of *silicic acid.* The most abundant of all minerals. One of the three ingredients of granite.

RHIZOPOD.—A *protozoan* form of life.

RUGOSITY.—Wrinkled, rough, corrugated.

RUN-OFF.—That portion of the rainfall which flows immediately from the surface without passing into the soil by *percolation.*

SEAWEED.—Plants living in sea water, particularly along the coast.

SEDIMENTARY ROCK.—A rock formed originally of sediment, *deposited* either by water, by air, or through the agency of animal or vegetable life. For example, sandstone is usually a sedimentary rock, having been formed by the *deposition* of sand which afterwards became consolidated by pressure, heat or other agencies.

SEEPAGE.—The oozing or *percolation* of water, particularly from flowing streams, irrigation ditches, etc.

SILICIC ACID.—A combination of the elements silicon and *oxygen.* The most common combination in the world. *Quartz* is silicic acid. Nearly three-fourths of the entire world structure consists of this material.

SILT.—A fine *textured* soil. Next to clay it is the finest of all soil in *texture.*

SOLUTION.—A liquid combination of a liquid and non-liquid substance. The change of matter from a solid or gaseous into a liquid state through its combination with liquid. Exactly what happens when a salt passes into solution is still a vexed question.

SPHAGNUM.—A form of moss particularly concerned in the formation of peat.

SPORE.—A reproductive body of plants which do not flower, including some *bacteria.* Spores are analogous to the seeds of higher plants. They are usually very resistant to conditions which may readily destroy their parent *organism.*

STALACTITE.—A tapering, icicle-like formation, usually of carbonate of lime, deposited by evaporation from *solution.* It commonly occurs in caves in limestone regions suspended from the roof.

STALAGMITE.—The counterpart of stalactite, rising from the floor upwards, caused by the dropping of *solutions* containing lime from the roof of the cavern.

STONEWORT.—A low form of plant life which has the power of extracting carbonate of lime from the water in which it grows. It frequently becomes encrusted with lime.

STRATIFIED.—Arranged in strata or layers, having been usually thus arranged as a result of *deposition.*

SUSPENSION.—Sediment held undissolved in moving water is said to be in suspension.

SYNTHESIZER.—An agency which combines relatively simple materials, *molecules* or elements, forming therefrom more complex materials, *molecules* or compounds. A plant is said to be a synthesizer in that it builds from the comparatively simple *molecules*, water, *carbonic acid gas*, *nitrates*, the complex *organic molecules*, protein, starch, fat, etc. The reverse of *analyzer* (which see).

TALUS.—The sloping mounds of broken and fallen rock fragments formed at the base of a cliff.

TERMINAL MORAINE.—(See moraine). A *moraine* located at the end of a *glacier*. This term is applied to the deposits stretching across the country from New Jersey to the State of Washington, marking the end of the continental *glacier*.

TEXTURE.—That method of arrangement and that character of the particles of a rock or soil which serve to distinguish it from others. As for instance, a slaty texture is very close, fine and compact, while the texture of a sandstone is relatively coarse.

THERMAL.—Pertaining to heat. A thermal spring is a hot spring.

TILL.—A heterogeneous mixture of clay, *silt*, sand, pebbles, cobbles, boulders, depositetd by the action of a *glacier* and unacted subsequently upon by moving water. *Glacial* soil are either tills in the condition of their original deposition or are clays, gravel, etc., as modified by the subsequent action of moving water.

TOPOGRAPHY.—The *physical* features as a whole which characterize any region. For instance, Vermont's topography is uneven in that it is made up of mountains, hills and valleys. Nebraska's topography, on the contrary, is flat.

TRANSPIRATION (leaf).—Exhalation or passing off as vapor from the surface of the leaves, of the water pulled up into the plant in the form of sap.

TRANSPORTATION.—A sub-process of *erosion*. The carriage of sediment, either *weathered* rock or soil, from one point to another (see page)

UNSTRATIFIED.—Not *stratified* (which see).

VERTEBRATE.—A vertebrate animal is one which has a backbone.

VISIBLE LOAD.—See load.

VULCANISM.—The phenomena attending volcanic action.

WATER-LOGGED.—A soil is said to be water-logged when its *pore* space is thoroughly filled with water.. A swampy soil is water-logged.

WATER TABLE.—The plane of saturation of a soil. That more or less horizontal plane below the surface of the soil indicating the upper boundary of the saturation of the soil.

WEATHERING.—The action more particularly of the air, and of *ground water* or rock surfaces, causing them to *disintegrate* and to *decompose*. See pages 214-215.

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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 144

AUGUST, 1909

Feeding Stuffs Inspection

Concerning Commercial Feeding Stuffs

I. Table of Contents, Summary and Introduction—Pages 3-8.
II. Results of Inspection—Spring 1909—Pages 9-17.
III. The Uses of an Inspection—Pages 18-21.
IV. Concerning the Manufacture of Feeds—Pages 22-34.
V. The Economics of Feeding—Pages 34-36.
VI. The Formulation of Grain Rations—Pages 37-44.
VII. Concerning Feeding—Pages 44-48.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 144: FEEDING STUFFS INSPECTION
CONCERNING COMMERCIAL FEEDING STUFFS

By J. L. Hills, C. H. Jones and P. A. Benedict

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SUMMARY

The sampling agents drew 189 samples representing 168 brands of goods, a few of which were deficient.

Eagle Brand, a cottonseed feed misbranded in that it was denominated a cottonseed meal, guarantied to carry 25 percent protein contained only 20 percent. Distillers' grains as a class were found as usual not to make good their inflated guaranties.

Certain feeds while meeting guaranties are deemed to be ill-advised purchases for the reasons stated:

Molasses feeds as a class; because of the likelihood that living weed seeds are used; because of the inferior nature of the absorbents used; because at ruling prices the digestible nutrients are relatively costly.

Flax feeds; because of the presence of weed seeds, either ground or unground; because of unknown feeding values; and because poisonous seeds may occur therein.

Cottonseed feeds; because it is unnecessary to import cottonseed hulls which have a low food value.

Oat feeds; because of the low feeding value of the extraneous oat hulls with which they all are more or less laden.

Alfalfa meals; because the payment of a concentrate price for hay even though it be ground is absurd. Pages 9-17.

The manufacture and nature of the several feeding stuffs are discussed at length, in order that the Vermont farmer may more clearly appreciate what is offered him. Pages 22-34.

The economics of feed purchase is a simple proposition and may be expressed in a nutshell. As sold in Vermont during the past season one could buy at retail for a dollar 23, 17, 15½, 11, or 6¼ pounds of protein, according to his choice; could pay from 4.4 to 16 cents per pound for this important nutrient, according to whether he took thought or trusted to a specious advertisement. Pages 34-39.

Sundry rations for cows, horses and poultry are suggested and statements afforded as to animal needs and the home growing of protein. Pages 40-48.

INTRODUCTION

It is many years since this station has issued any publication having to do in a broad way with matters of stock feeding. It has discussed several specific experiments in dairy feeding and printed the results of the semi-annual feeding stuff inspection, but it has issued nothing dealing specifically with the principles and practice of stock feeding since bulletin 81, printed in 1900 and now for many years nearly out of print.

The appropriation available for the enforcement of the feeding stuff inspection law is but $500. From this meagre sum hitherto has been paid not only the expenses incurred in connection with the semi-annual sampling trips and analyses, but also the cost of preparation, of printing and of distribution of two bulletins annually. The printer's bills have consumed from one-fourth to one-third of the entire appropriation. Now, however, that the station publications come within the purview of state printing, somewhat better inspectional work may be done with that portion of the funds hitherto paid the printer; and under that provision of the statutes which permits the purveyal of such "additional information in relation to the character, composition, value and use of feeding stuffs as circumstances may advise" it becomes possible to do more than simply issue an eight-page, boiled down summary of analytical results, and to supply some "additional information" having to do with stock feeding matters and the use of feeding stuffs.

THE FEEDING STUFFS LAW.

The term "concentrated commercial feeding stuffs" is defined both inclusively and exclusively. As used in the statutes and for the purposes thereof it is held to include "linseed meals, cottonseed meals, cottonseed feeds, pea meals, cocoanut meals, gluten meals, gluten feeds, maize feeds, starch feeds, sugar feeds, dried distillers' grains, dried brewers' grains, malt sprouts, hominy feeds, cerealine feeds, rice meals, oat feeds, corn and oat chops, corn and oat feeds, corn bran, ground beef or fish scraps, meat and bone meals, mixed feeds other than those composed solely of wheat bran and middlings mixed together or with pure grains, provenders other than those composed of pure grains ground together, condimental stock and poultry foods, patented proprietary or trade-marked stock and poultry foods and other materials of a similar nature not named in the following section:" (Sec. 4983).

The term "concentrated commercial feeding stuffs" is held *not* to include "hay and straw, the whole seed nor the unmixed meals made directly from the entire grains of wheat, rye, barley, oats, Indian corn, buckwheat, India wheat and broom corn; nor shall it include wheat, rye and buckwheat bran or middlings not mixed with other substances but sold separately as distinct articles of commerce, nor wheat bran and middlings mixed together and not mixed with other substances, nor pure grains ground together, when unmixed with substances other than wheat, rye or buckwheat bran or middlings." (Sec. 4984 P. S.)

The statutes provide that "every lot . . . of concentrated commercial feeding stuff . . . used for feeding farm livestock . . . . shall have a . . . statement . . . . certifying the . . . net pounds, . . . the . . . brand, . . . the name and address of the manufacturer, ... and a chemical analysis stating the minimum percentages of crude protein it contains, allowing one percent of nitrogen to equal six and one-fourth percent of protein, and of crude fat, and the maximum percentage it contains of crude fiber; provided that the statement of the percentage of crude fat may be omitted if it does not exceed three percent and that of crude fiber if it does not exceed ten percent. If . . . . sold in bulk at retail or put up in packages belonging to the purchaser . . . . the certified statement (shall be furnished on the purchaser's request). (Sec. 4985 P. S.).

It provides that any person offering unguarantied, or overguarantied goods shall be subject to fine (Sec. 4986 P. S.); prohibits adulteration of "whole or ground grain with . . . offals, or with a foreign substance, or (of) bran or middlings, ... (or) mixed feed, with a foreign substance . . . . unless the . . . adulteration thereof is . . . . indicated"; forbids the use of "materials containing weed seeds . . . . in excess of two percent . . . . . unless such use . . . . . . is indicated"; and provides penalties for the sales of goods thus sophisticated. (Sec. 4987 P. S. as amended in 1908).

It provides for an annual appropriation of $500 (Sec. 4987 P. S.) for sampling, analyses, and publication (Sec. 4990-4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing, or purchasing feeding stuffs for their own use and not for sale in this state." (Sec. 4992 P. S.).

SAMPLING

The sampling agents of the Station visited 26 towns and villages in Vermont during the spring of 1909 and drew 189 samples from dealers' stocks, representing 168 brands of goods either subject to or exempt from the necessity of guaranty. These samples have been examined chemically for protein and in some cases for crude fiber, and in the case of doubt appeal has been made to the microscope. Inasmuch as there is no license or brand tax system in vogue in Vermont no track can be kept as to the numbers of brands sold. Without doubt a great many kinds of feeds are sold, samples of which never reach the station laboratory. Both guarantied and unguarantied goods are examined, the former to determine so far as may be their purity as well as the maintenance of the standards fixed by their makers; the latter to determine if possible whether as a matter of fact the goods are pure and not subject to guaranty.

II. RESULTS OF INSPECTION: SPRING 1909

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
COTTONSEED MEALS			
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41.	39.
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41.	39.6
F. W. Brodé & Co., Memphis, Tenn.	Owl	41.	40.7
F. W. Brodé & Co., Memphis, Tenn.	Owl	41.	40.8
Hunter Bros. Milling Co., St. Louis, Mo.		41.	43.8
T. H. Bunch Co., Little Rock, Ark.	Old Gold	41.	38.3
American Cotton Oil Co., Memphis, Tenn.	Choice	41.	41.
American Cotton Oil Co., Memphis, Tenn.	Choice	41.	41.3
Blackstone Smith, New Orleans, La.	Purity	39.	40.5
H. E. Bridges & Co., Memphis, Tenn.		41.	42.2
Buckeye Cotton Oil Co., Greenwood, Miss.	Buckeye	39.	40.2
COTTONSEED FEEDS			
American Brokerage Co., Memphis, Tenn.	Eagle	25.	20.3
Humphreys, Godwin & Co., Memphis, Tenn.	Seed Meal	22.	26.1
LINSEED MEALS.			
American Linseed Co., Chicago, Ill.	New Process	36.	38.8
American Linseed Co., Chicago, Ill.	Oil Meal	36.	38.6
American Linseed Co., Chicago, Ill.	Old Process	32.	37.5
American Linseed Co., Chicago, Ill.	Oil Meal	32.	37.4
Midland Linseed Co., Minneapolis, Minn.	Old Process	32.	36.4
GLUTEN FEEDS			
Corn Products Refining Co., Chicago, Ill.	Buffalo	23.	26.4
Corn Products Refining Co., Chicago, Ill.	Pekin	23.	27.
Corn Products Refining Co., Chicago, Ill.	Crescent	23.	25.9
American Maize Products Co., New York	Cream of Corn	23.	24.8
Douglass & Co., Cedar Rapids, Ia.	Cedar Rapids	22.	24.1

DISTILLERS' DRIED GRAINS

		GUAR.	ANAL.
J. D. Page & Co., Syracuse, N. Y.	Empire State Dairy Feed.	28	28.2
Ajax Milling and Feed Co., Buffalo, N. Y.	Ajax Flakes	31.	28.6
Deutsch and Sickert Co., Milwaukee, Wis.	Climax Grains	34.	31.2
St. Albans Grain Co., St. Albans, Vt.	Bourbon Grains	29.8	30.4

BREWERS' DRIED GRAINS

Atlantic Export Co., Milwaukee, Wis.		25.	27.2
Anheuser-Busch Brewing Co., St. Louis, Mo.		24.	26.1

PROPRIETARY ARTICLES LARGELY COMPOSED OF DISTILLERS' OR BREWERS' GRAINS

J. W. Biles & Co., Cincinnati, Ohio	Union Grains	24.	24.4
Ajax Mill and Feed Co., Buffalo, N. Y.	Unicorn Dairy	26.	27.3
St. Albans Grain Co., St. Albans, Vt.	Paragon Dairy	28.	30.4
St. Albans Grain Co., St. Albans, Vt.	Paragon Dairy Ration	24.	27.4

FLAX FEED

Henry Jennings, Boston, Mass.	H. J.	17.34	16.2

MOLASSES FEEDS

Amer. Milling Co., Chicago, Ill.	Sucrene Dairy	16.5	18.4
Amer. Milling Co., Chicago, Ill.	Sucrene Horse and Mule	10.	10.5
Sugarine Co., Chicago, Ill.	Sugarine Dairy	16.5	18.
North-West Mill Co., Winona, Minn.	Sugarota Dairy	18.	18.1
International Sugared Feed Co., Minneapolis, Minn.	Natl. Sugared	16.5	18.3
Quaker Oats Co., Chicago, Ill.	Molac Dairy	16.	17.6
Great Western Cereal Co., Chicago, Ill.	Daisy Dairy	14.	14.3

CORN AND OAT FEEDS

Quaker Oats Co., Chicago, Ill.	Schumaker Stock	10.	11.2
Charles M. Cox Co., Boston, Mass.	Wirthmore Stock	10.	9.6
Quaker Oat Co., Chicago, Ill.	Victor	7.5	7.6

		GUAR.	ANAL.
Commercial Milling Co., Detroit, Mich.	Henckels Corn and Oat	9.	9.4
Great Western Cereal Co., Chicago, Ill.	Sterling Stock	10.	11.1
Griswold and McKinnon, St. Johnsbury, Vt.	Special Provender	7.63	9.1

HOMINY FEEDS

American Hominy Co., Indianapolis, Ind.,	Homco	8.5	10.0
Husted Milling Co., Buffalo, N. Y.	Germaline	9.	9.4
St. Albans Grain Co., St. Albans, Vt.			11.2
Toledo Elevator Co., Toledo, Ohio	Star*	7.	9.1

PROVENDERS

A. F. Davis Feed Co., Rutland, Vt.			9.2
Burditt Bros., Rutland, Vt.			9.9
B. S. Hooker, Bradford, Vt.			10.4
A. N. Washburn Co., Bethel, Vt.			10.
W. F. Edson, Randolph, Vt.			10.1

WHEAT BRANS

New Prague Milling Co., New Prague, Minn.	Seal of Minn.	14.	14.
Northwestern Consolidated Milling Co., Minneapolis, Minn.	Pure	14.25	15.6
Hunter Bros. Milling Co., St. Louis, Mo.	Pure	14.	16.7
Thomas Page	Mid Continent	14.	17.8
Gardner Mill, Hastings, Minn.	Clover Leaf	14.3	15.6
Bay State Milling Co., Winona, Minn.	Winona	16.	16.4
Marcus Bernheimer Flour Mills Co.	Banner	14.5	17.1
Kemper Mill and Elevator Co., Kansas City, Mo.	Anchor	14.5	17.
Cain Milling Co.	Cains'	13.	15.9
Chapin and Co., St. Louis, Mo.	Pure	14.	16.6
Cataract Milling Co.	Niagara	14.78	16.1
Crosby Roller Mill Co.	Crosby's Pure	14.	16.
Pillsbury Milling Co., Minneapolis, Minn.	Pillsbury's	13.	14.9
Southwestern Milling Co., Kansas City, Mo.		15.	16.1
Christian & Co.		15.	15.

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*See text page 20.

		GUAR.	ANAL.
Barber Milling Co.,	Flakes	13.	15.9
Washburn Crosby Milling Co., Minneapolis, Minn.	Pure	14.	15.8
Washburn Crosby Milling Co., Minneapolis, Minn.	Unadulterated, Coarse	14.	15.4
Hennepin Milling Co., Minneapolis, Minn.	Ben Hur	14.	15.4
Lyon & Greenleaf Co., Warsaw, Ohio			15.
Henry Russell, Albany, N. Y.	H.		13.3
Ogdensburg Roller Mills Co., Ogdensburg, N. Y.	Choice		14.8
Charles M. Cox Co., Boston, Mass.			16.6
St. Albans Grain Co., St. Albans, Vt.	Kansas		15.8
St. Albans Grain Co., St. Albans, Vt.			17.

WHEAT MIDDLINGS

		GUAR.	ANAL.
Consolidated Milling Co.	XXX Comet*	18.25	17.9
Washburn Crosby Milling Co., Minneapolis, Minn.	Flour	17.	18.1
Washburn Crosby Milling Co., Minneapolis, Minn.	Adrian Flour	17.	18.9
J. A. Cole Milling Co. Rochester, Minn.	Rochester Flour	17.5	17.4
Hennepin Milling Co., Minneapolis, Minn.	Ben Hur Standard	15.	16.4
Bill Bell & Co., Ogdensburg, N. Y.	White		17.9
National Milling Co., Minneapolis, Minn.	Hardenburg's White	16.	14.5
Pillsbury Milling Co., Minneapolis, Minn.	Pillsbury's B.	14.	16.6
Pillsbury Milling Co., Minneapolis, Minn.	XX Daisy	16.	17.4
New Occidental Milling Co.	Alora	16.	16.8
Washburn Crosby Milling Co., neapolis, Minn.	Standard	15.	17.
Valley City Milling Co., Grand Rapids, Mich.	Vimco	15.84	16.3
Northwestern Consolidated Milling Co., Minneapolis, Minn.		17.75	16.5
W. M. Coombs Milling Co., Cold Water, Michigan		15.	18.1
Detroit Milling Co., Detroit, Mich.	Apex	18.	15.6
Ansted and Burk Co.		14.5	16.9
Cataract City Milling Co.,	Niagara Standard		16.7
Voigt Milling Co., Grand Rapids, Mich.	Voights'		15.7
Valley City Milling Co., Grand Rapids, Mich.	Vimco		15.4

ERRATA

*These goods were erroneously listed in the last feeding stuff bulletin (No. 138) under the head of molasses feeds. Moreover, the guaranty statement was incorrect. It should have read 18.3 percent rather than 10.8.

		GUAR.	ANAL.
Amendt Milling Co., Munro, Mich.	Amco		16.2
Washburn Crosby Co., Minneapolis, Minn.	Standard	16.	16.9

RED DOG FLOUR

		GUAR.	ANAL.
St. Albans Grain Co., St. Albans, Vt.			18.1
Hennepin Milling Co., Minneapolis, Minn.	Ben Hur	17.	19.3
McCrillis and Son	Powerful Red Dog	18.25	17.7
Berger Crittenden Milling Co., Milwaukee, Wis.	Berger	18.	17.4

WHEAT MIXED FEEDS

		GUAR.	ANAL.
Commercial Milling Co.	Waumbeck	15.	16.2
Russell Miller Co., Minneapolis, Minn.	Occident	15.	16.9
Duluth Milling Co., Duluth, Minn.	Boston	16.	16.
Pillsbury Co., Minneapolis, Minn.	Pillsbury's Fancy	14.	16.2
Pillsbury Co., Minneapolis, Minn.	Pillsbury's Fancy	14.	15.9
Washburn Crosby Co., Minneapolis, Minn.	Superior	18.	16.8
Charles M. Cox Co., Boston, Mass.	Wirthmore	16.	16.3
Williams Bros.	Kent's Mid'gs and Bran	14.	15.8
Williams Bros.	Kent's	12.	15.6
Hunter Bros. Milling Co., St. Louis, Mo.	Sunshine	16.	17.3
Hunter Bros. Milling Co., St. Louis, Mo.		15.	17.2
Annan Burger & Co.	A. B. C.	14.	16.5
Barker Milling Co.	White Star	16.	16.9
Hunter Bros. Milling Co., St. Louis, Mo.	Matchless	15.	15.9
Chapin & Co.	Vermont	14.	16.8
Aughenhaugh & Co.	Eaco Winged Horse	15.	17.1
Griswold & McKinnon, St. Johnsbury, Vt.	Xtra Good	16.	15.9
Hennepin Milling Co.	Ben Hur	16.	16.3
Sheffield Ring Co.	Gold Mine	17.	16.1
National Milling Co., Toledo, Ohio	Pennant		15.7
Henry Russell, Albany	Regular		16.4
Stratton & Co., Concord, N. H.			15.2
N. M. Co., Noblesville, Indiana			15.7
St. Albans Grain Co., St. Albans, Vt.	Hygrade		15.6
Alma Roller Mills, Alma, Mich.	Alma		15.2

		GUAR.	ANAL.
Waggoner & Gates, Independence, Mo.			17.6
Chapin & Co., St. Louis, Mo.	Erie Winter		18.3
E. W. Bailey & Co., Montpelier, Vt.			15.8
Portland Milling Co.	Champion		14.8
A. H. McLeod Milling Co., St. Johnsbury, Vt.	Brook's Fancy		16.1
Charles M. Cox Co., Boston, Mass.	Regent		17.1
F. W. Stock & Sons, Hillsdale, Mich.	Stock's Superior		14.5
Garland Milling Co.	Garland	15.25	15.9
Charles M. Cox Co., Boston, Mass.	Eagle		16.4

POULTRY FOODS

Charles M. Cox Co., Boston, Mass.	Wirthmore Mash	20.	20.2
Charles M. Cox Co., Boston, Mass.	Scratch	10.	10.9
A. H. McLeod Milling Co., St. Johnsbury, Vt.	Fancy Scratching		10.9
Buffalo Cereal Co., Buffalo, N. Y.	Scratching		10.8
Quaker Oats Co., Chicago, Ill.	Schumaker's Scratching.	10.5	11.3
Carroll S. Page, Hyde Park, Vt.	Page's Perfected	24.	22.5
Burlington Rendering Co., Burlington, Vt.	Burlington Beef Scraps	40.	47.5
Park & Pollard Co., Boston, Mass.	Dry Mash	22.	20.6
Park & Pollard Co., Boston, Mass.	Growing	14.	14.7
Park & Pollard Co., Boston, Mass.	Snow Flake Scratch	10.	9.8
Park & Pollard Co., Boston, Mass.	Screened Scratch	10.	10.8
Park & Pollard Co., Boston, Mass.	Gritless Chick	13.77	11.5
Park & Pollard Co., Boston, Mass.	Intermediate Chick	10.	10.5
Park & Pollard Co., Boston, Mass.	Fattening	10.	9.5

ALFALFA MEAL

Great Western Cereal Co., Chicago, Ill.	Great Western	14.	15.8
Newton Alfalfa Mills	Alfalfa		16.3

CORN MEAL

Buffalo Cereal Co., Buffalo, N. Y.			9.1
Buffalo Cereal Co., Buffalo, N. Y.	Yellow Seneca		9.9

RYE MIDDLINGS

	GUAR.	ANAL.
Washburn Crosby Milling Co., Minneapolis, Minn.	14.	16.2
Bowtill Milling and Grain Co.		15.4

MISCELLANEOUS

Blatchford Calf Meal Factory, Waukegon, Ill.	**Calf meal**	25.	27.6
Peels Remedy Co., Brattleboro, Vt.	**Peels Condition Food**		12.8
Pratt's Food Co., Philadelphia, Pa.	**Pratt's**		10.9

CONCERNING THE RESULTS OF INSPECTION

Cottonseed meal. Three brands out of eleven (two of Dixie bearing the same protein but different fat figures, and one of Old Gold) were respectively 1.4, 2., and 2.7 percent below guaranties.

Cottonseed feed. Two samples of this material were found. It is a highly uneconomical class of goods, is guarantied to carry but 22 percent to 25 percent of protein and sells usually at prices only a few dollars less than that at which straight cottonseed meal is sold. To one of these particular attention must be drawn. The "Eagle Brand of cottonseed meal; a guaranty of satisfaction and quality" was found at a point in Orange county guarantied to contain 25 percent protein and carrying but 20.3. These goods although an undesirable purchase would have been legal so far as name is concerned had they been called a feed instead of a meal, and had they maintained their guaranty. But masquerading under a misleading title and carrying but 80 percent of the protein content promised, they constitute a flagrant violation of the law, which has been called to the attention of the State's Attorney of Orange county.

Linseed meal. Five samples were found running unusually high, making good their protein statements.

Gluten feeds. Five samples made good their protein guaranties.

Distillers' dried grains. Half of the brands were below and decidedly below guaranty. This situation has become chronic with this class of goods. Letters of remonstrance to the manufacturers and to jobbers outside Vermont are usually either answered in an unsatisfactory manner or no reply whatever is made, and no proper explanations are vouchsafed. Such repeated failure to maintain self-imposed guaranties must shortly result in appeal to the penal sections of the law. It is a great pity that so admirable a feed should be thus delinquent. However, unfavorable reports and court proceedings, if such ensue, should not be held by the feeder to warrant either the condemnation or non-use of distillers' grains. It is simply a matter of failure on the part of the manufacturers to live up to a self-imposed standard, a case of persistent over-promising. The guaranty of one brand as a result of much correspondence has been reduced to a figure more nearly in consonence with its facts. It is trusted that other jobbers will profit by this example.

Brewers' dried grains. Four samples exceeded guaranties by a liberal margin.

Flax feed. One sample was short of guaranty.

Molasses feeds, oat feeds, corn and oat feeds. Seven brands each of molasses feeds and of corn and oat feeds made good their protein promises, some of which were so low as to make it difficult for them to fail to do so.

Hominy feeds. Three lots "made good." A hominy product denominated "Star Feed" deserves special mention. These goods, selling at the same price as strict hominy feed but guarantied to contain only three-fourths as much protein and carrying a guaranty of over 12 percent crude fiber, an amount which cannot by any possibility be present in a normal hominy feed, were evidently extended with ground corn cobs or some similar fibrous material. The fact, however, that they carry a guaranty statement and that they are called "Star Feed" rather than hominy feed makes their sale legal.

Wheat offals. Twenty-five brans, 21 middlings, 4 red dog flours (feed flour) and 34 mixed feeds were tested. The larger share of these were guarantied in accordance with the laws of several states. Bran guaranties ranged from 13 to 16, middlings from 14 to 18, red dog from 17 to 18.25, and mixed feed from 12 to 18 percent protein. No guaranty being required in Vermont, the maintenance thereof is not legally a vital matter. Only two lots of middlings, (National Milling Co. and Detroit Milling Co.) and a mixed feed put out by the Washburn Crosby Co. failed to make good the claims of their makers. The latter brand, however, carried an inordinately high guaranty and was full better than the average. The following goods whether guarantied or not, whether making the guaranties good or not, carry lower protein contents than good average products should contain.

Bran, New Prague Milling Co.	**14.**
Bran, Henry Russell & Co., Albany	**13.3**
Middlings, National Milling Co.	**14.5**
Mixed feed, Portland Milling Co.	**14.8**
Mixed feed, F. W. Stock & Sons	**14.5**

It should be clearly understood, however, as before stated, that so far as the Vermont law is concerned guaranties of wheat offals are extra-legal and their maintenance not essential.

Poultry foods. Two out of 14 lots failed by not very large figures to meet their manufacturer's guaranties; Page's Perfected Poultry Food by 1.5 percent and Park and Pollard's Dry Mash by 1.4 percent.

AS TO GUARANTIES

The guaranty requirements are now very generally lived up to with sacked goods. The sale of bulk goods, however, taken directly from the car or for bulk stock is less well protected. The statutes do not require the furnishment of guaranties save "upon request of the purchaser." It is suggested, however, that the guaranty statement furnished by the manufacturer or jobber be displayed in connection with the lot it covers, by affixing it to the bin.

III. THE USES OF AN INSPECTION

Of what use may one find a feeding stuff inspection?

1. It serves as a protection against sophistication.

2. It affords some clue as to whether the brand name is or is not misleading.

3. It permits of the determination of the validity of manufacturer's promises.

4. It allows the buyer to judge whether the goods offered are or are not of normal grade.

5. It enables comparison between feeds on a uniform basis.

6. It aids the buyer in his decision whether the price asked is or is not reasonable.

7. It furnishes data for ration computation and compounding.

1. *The detection of adulteration.* The law forbids specific sorts of adulteration, but cannot cover all forms. Moreover, certain kinds, like the use of cottonseed hulls in over large quantities in cottonseed meal, are quite difficult to prevent. But chemical analysis, the use of the "water cure," (see page 24) etc., in short a careful study of analytical results will serve to warn the buyer. Similarly with goods laden with weed seeds and with feeds masquerading as provenders but heavily laden with oat hulls, station analyses prove enlightening.

2. *The misleading brand name.* "A rose by any other name would smell as sweet," but its name would not suggest its perfume. Screenings from wheat elevators and from flax seed are not made more desirable when bedaubed with molasses and sold as molasses feeds, or when in an uncrushed condition they are so named as to convey the impression that they are flax seed or akin to the well known and highly prized linseed meal. The statements of the inspection should serve to warn the buyer as to the false impressions thus conveyed by specious names. It is interesting to note in this connection the relation of the nomenclature of feed brands to their actual food values. Thus in a New England station inspection bulletin are found the following

modest names applied to goods carrying less than 10 percent of protein: Matchless, Wirthmore, Jersey, Blue Grass, Victor, Eclipse, Monarch, Excelsior, Boss, Star; in another: Peerless, XX, Empire, Best, Royal,, Jim Dandy, O. K., Complete. The only terms in either bulletin applied to goods carrying more than 25 percent protein which are in the least grandiloquent or suggestive of quality, are the words "Prime" and "Choice," used in connection with cottonseed meal being recognized trade terms indicating definite grades, Ajax XXXX, Blue Ribbon, Climav, Star, Imperial, Eagle, Green Diamond, Old Gold; and four of the latter are trade names employed apparently in order to avoid the use of the—to some—objectionable and suggestive term distillers' grains. In the feed trade, as in the fertilizer trade and doubtless others, bombastic terminology is often used to attract and in some measure to gloss over the low grade of the sales product.

3. *The maintenance of guaranties.* Manufacturers and jobbers establish their own guaranties; but owing to the natural variation in the quality of raw materials, to changes or vagaries in manufacturing processes, or to other and less excusable causes, these promises are not always kept. The comparison of analysis with guaranty affords ample information as to the validity of the latter.

4. *The grade of the goods.* The grade of grain and of grain by-products is not entirely determined by chemical analysis. Several other factors enter into the matter. But so far as their service in stock feeding is concerned the protein percentage is a dominant factor. The average protein percentage of normal products is known and the comparison of an individual analysis therewith is readily made.

AVERAGE PROTEIN AND FAT CONTENTS OF FEEDS

To the end that Vermont buyers may have some notion as to standards, the following table of averages compiled from the results as shown in recent Massachusetts, Connecticut and New Jersey bulletins are offered as indicating closely the probable average composition in protein and fat of the goods more commonly offered on the Vermont markets.

I. GOODS CARRYING MORE THAN 30 PERCENT PROTEIN

	Protein.	Fat.
Cottonseed meal	41.	9.5
Linseed meal (new process)	36.8	2.8
Linseed meal (old process)	34.1	7.6
Distillers' dried grains (first grade)	31.6	13.1

II. GOODS CARRYING 25 TO 30 PERCENT PROTEIN

	Protein.	Fat.
Buckwheat middlings	29.1	7.5
Distillers' dried grains (second grade)	27.5	11.5
Brewers' dried grains	26.1	7.1
Malt sprouts	26.5	1.5

III. GOODS CARRYING 20 TO 25 PERCENT PROTEIN

	Protein.	Fat.
Gluten feeds (as a class)*	23.7	3.0
Union grains	24.1	7.2
Unicorn dairy ration	25.4	6.0

IV. GOODS CARRYING 15 TO 20 PERCENT PROTEIN

	Protein.	Fat.
Molasses feeds (as a class)† exclusive of horse feeds	16.2	3.4
Flax feed	16.3	14.5
Wheat middlings	17.1	5.1
Wheat mixed feed	16.2	4.8
Wheat bran	15.2	4.7

V. GOODS CARRYING 10 TO 15 PERCENT PROTEIN

	Protein.	Fat.
Molasses feeds for horses (as a class)	12.4	3.3
Fortified oat feeds	12.9	3.8
Alfalfa meals (as a class)	13.1	1.3
Hominy meal	10.5	8.4
Ground oats	10.6	4.8
Corn bran	10.3	7.7

VI. GOODS CARRYING 5 TO 10 PERCENT PROTEIN

	Protein.	Fat.
Corn and oat feeds (as a class)	9.2	5.1
Provender	9.2	4.3
Oat feeds (ordinary) (as a class)	6.8	3.1
Corn meal	8.9	3.4

5. *The comparison between feeds.* A letter in hand as this matter is being prepared for the press sent by a dealer in northern Vermont states that he contemplates the manufacture of a feed

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*Subject to wide variation.

†Subject to considerable variations.

for sale, mixed from named ingredients, making thus "a better feed than (he) can buy." The writer's opinion was not asked as to its make-up, but he would consider it for dairy purposes to be distinctly inferior to many feeds now in the market or which might be readily compounded by a good feeder of stock. When one who is well informed as to feeding matters compares the analyses of sundry feeding stuffs, some—not all— of the information needed as to comparative values is thus furnished.

A low price is not usually indicative of a cheap article, using the term cheap in the sense of economical. It is apt to indicate a cheap article using the phrase in the sense of inferior. Neither does a high price indicate necessarily an exalted order of merit. Price in short affords no certain criterion as to grade. The protein guaranty of the goods is apt to be a better guide to the purchase of dairy feeds than is name or price.

6. *The cost of feeds.* A recent bulletin from a nearby state indicates that goods carrying from 30 to 41 percent protein sold during the winter of 1908-09 for from $31 to $34 a ton; those carrying from 20 to 30 percent protein at from $25.50 to $37 at ton; those carrying from 15 to 20 percent protein at from $24.50 to $38; while two oat feeds of royal lineage—judging by their names—but of low protein content sold for $31 and $34. In the higher grade goods 21 pounds of protein were bought for a dollar; in the two lower 7⅓ and 5 pounds. Further comment is needless as to the service of the inspection in this respect.

7. *Compounding of rations.* This best use of the information afforded by the analyses is made by the feeder who has studied the art of ration formulation. He alone profits thereby to the full extent, although not infrequently the uninformed dairyman blindly accepts the dictum and the practice of his better informed brethren. To the end that the wilfully blind may be led and that he who would see may be informed, the matter on pages 40-48 has been prepared.

IV. CONCERNING THE MANUFACTURE AND NATURE OF THE SEVERAL CLASSES OF FEEDS OFFERED ON VERMONT MARKETS

COTTONSEED MEAL

This by-product of the manufacture of cottonseed oil is sold in several different grades. The Cottonseed Crushers' Association have established the grades of "Choice," "Prime" and "Off." A choice meal is one which is "finely ground, perfectly sound and sweet in odor, free from excess of lint and hulls, and by analysis shows an equivalent of 41.15 percent protein." A prime meal is one which is "finely ground, of sweet odor, reasonably light in color and showing a protein equivalent of 36 percent." An off meal includes an excess of lint and hulls and is distinctly deficient in any one or more of the requirements of prime quality, such as color, texture, odor or analysis.

Up to about three years ago the shippers guarantied 43 percent protein in the higher grade or "choice" goods; but of late the protein guaranty has been reduced to 41 percent, and moreover during this time there have been several failures to maintain even this lower standard. This has been due chiefly to a too great admixture of cottonseed hulls and lint with the meal.

To the end that the readers of this bulletin and the users of this product may have a clearer conception than perhaps they now have of the way in which this important feeding stuff is made, a brief description of the manufacturing process follows:

The cotton bolls as they come from the field pass through a mechanism known as a gin which removes the larger part of the fiber. The seeds, closely covered with a fine textured short lint, pass thence to the oil mill. Here they are screened to remove sticks, dirt, etc., and are passed through a special gin known as the delinter gin which removes the last traces of these fine fibers. The seeds are then ground or, rather, cracked, and are passed upon a revolving screen so arranged that the meats fall through its meshes while the hulls and other offals roll out at the end as tailings. This serves to separate the meats high in protein from the hulls which are low therein. The former are then steam heated, after which the cooked mass placed in coarse sacks is subjected to hydraulic pressure, which removes the oil leaving the residue in the form of hard cakes. These hard, corrugated, board like masses are sold in this shape in immense quantities in Europe for cattle feeding purposes. In this country, however, it is customary to grind the boards into meal, forming a bright yellow powder, of a sweet and nutty flavor and pleasant aromatic odor.

The dull or, indeed, dark color occasionally observed is ordinarily due to either one or more of four causes:

1. Overheating during the cooking process.
2. Fermentation prior to the heating process.
3. Improper or over long storage.
4. Undue admixture of hulls.

The latter cause lessens the value of the product; the third unfits it for stock feeding purposes; the first and second do not materially affect its composition thought they somewhat impair the feeding value.

A small amount of lint and of hulls inevitably enters into the composition of the best of meals. It is difficult or impossible entirely to remove them. But there is doubtless a larger proportion of these materials included now than formerly and more than is necessary. The demand for cottonseed meal has increased so rapidly of late that it has more than overtaken the supply; hence oil mill companies are tempted to include as much of these offal products within the meal as practicable. In some cases this has gone to such an extent that the product is quite dark in hue and decidedly inferior. It does not follow that all dark colored meals are necessarily diluted. It may be due, as above noted, to heating, over-cooking or to other causes. The composition may not be lowered if this is the fact, but the quality is impaired. When, however, the color is due to the admixture of hulls both the composition and the quality are lowered.

One can quite readily for himself determine the presence of any material amount of hulls in a lot of meal without submitting it to analysis. The method suggested in bulletin 101 of this station is very simple and tells the story quickly.

"Place a teaspoonful of the meal (do not use more) in a tumbler and pour over it from an ounce and a half to two ounces of hot water. Stir the mass till it is thoroughly wet up and all the particles are floating. Allow it to subside for from five to ten seconds and pour off. If a large amount of fine, dark brown sediment has settled in this time, a sediment noticeably heavier than the fine, mustard-yellow meal, one which upon repeated treatments with boiling hot water keeps settling out, the goods are a feed meal, i. e. a meal containing relatively large quantities of ground hulls. All meals contain small quantities of hulls and show dark specks. If, however, there is found a large amount of this residue, one which persists in remaining behind after several washings and decantings, it is surely composed of hulls and the goods are a feed meal. The results of this test are very striking when a feed meal is compared with a meal of known purity which is similarly tested at the same time. Buyers are urged to try this simple but effective test, and to send to the station for its analysis any sample of which they feel suspicious."

Cottonseed feed (cottonseed meal feed, or feed meal, several terms are used) is occasionally found in Vermont markets. This is a material which may have anywhere from 15 to 25 percent of protein and is made from the admixture of considerable quantities of cottonsed hulls with the regular meal. In some cases over half the product is composed of hulls. It is not an economical feeding stuff for the Vermont farmer to purchase.

LINSEED OIL MEAL

Linseed meal, oil meal and, sometimes, flax seed meal, are trade names which are commonly applied to the by-product of the linseed oil industry. The material is made by the grinding of flax seed, from which most of the oil has been removed either by hydraulic pressure (old process) or by extraction with naphtha (new process). The larger share of the meal now upon the market is of the latter type. The new process meal is apt to contain rather more protein and somewhat less fat than does old process meal. The one may be distinguished from the other very readily if desired by stirring a tablespoonful in a glass tumbler to which is added ten tablespoonfuls of boiling hot water. The new process meal after being stirred for a little while settles to the bottom, whereas the old process meal forms a sort of jelly with the water and does not readily settle.

Linseed meal ordinarily commands a somewhat higher price than does cottonseed meal, although the last year or so this has not always been the case. It is a safer and in some ways a more desirable feed than is cottonseed meal. The large European demand sufficiently explains its high price, a demand great enough to keep the price at a figure higher as compared with cottonseed meal than its protein content would seem to warrant. However, as compared with any other product upon the market the protein in linseed meal at even this high figure is a cheap purchase.

GLUTEN MEALS AND FEEDS

These materials are by-products of the manufacture of starch and glucose. The maize kernel carries very large amounts of starch which are largely removed in the manufacture of these two products, leaving the by-product relatively rich in oil and in protein. The oil is quite generally removed for other purposes leaving the final residue comparatively free therefrom.

Gluten meals are not now offered for sale in Vermont. Gluten feeds are admixtures of gluten meal with the bran or outer integument of the corn kernel. These materials have had large vogue among dairymen and have been found as a class a desirable feed, but one of uneven composition. Many different brands are upon the market varying in protein content all the way from the upper to the lower twenties or even the upper teens. Until recently these goods as a class have tended to underrun their guaranty statements, but recently these have been lowered to more nearly meet the facts.

The process of manufacture is essentially as follows: The corn kernels are steeped in water containing small amounts of dilute mineral acid—sulphurous or hydrochloric—and are then ground. These acids are later neutralized forming innocuous salts. The corn bran and the more glutenous portions are separated by mechanical means from the residue and dried, forming gluten feed. The steep water soaks out certain of the soluble portions, which possess some food value. Hence it has been customary to evaporate these waters, to mix the same with the gluten feed, and then to dry the mixture. The feed thus made is of a duller hue than is the old type gluten feed. Moreover, when white corn is handled a dull color is secured. Consequently certain manufacturers have at times made use of an analine dye in order to attain a uniform color. The quantity used is not sufficient to be in any way injurious to health. However, coloring the product adds nothing to its food value. The use of this dye is probably contrary to the provisions of the National Food and Drug Act. The fact of such use is stated upon some of the packages when the dye is used.

DISTILLERS' DRIED GRAINS

These materials, sold usually under names which give no clue to their origin, such as Biles XXXX, Climax Grains, Ajax Flakes, Empire State Dairy Feed, Corn Protegran, Blue Ribbon Grains, etc., are a residue of the manufacture of whiskey or of alcohol. Certain grains, usually corn and to some extent oats or a mixture of the two, and at times rye, are ground fine, mixed with water and cooked to disintegrate the starch. This is then converted into sugar, usually by the action of barley malt, and heat is applied which serves to ferment the sugar and to form alcohol. Then finally the semi-fluid mass, known technically as the "mash," is pumped into a closed vat or still from which the alcohol as well as other products are volatilized by heat, thus forming the liquor or spirits. After the alcohol has been driven off the cooked semi-liquid "distillers' slop," containing all that was originally in the grains other than the converted starch, is drawn from the still and is kiln dried for use as cattle food. These grains then are simply the by-products of the manufacture of alcohol, spirits, and whiskey, the kiln-dried residues from the stills. They contain no alcohol, but, because of the fermentation which they have undergone, possess a peculiar and characteristic odor, which, however, is not at all disagreeable. There are generally three grades made, one from the distillation of alcohol and spirits, a second from the distillation of bourbon whiskey, and a third from that of rye whiskey. The first named is the higher in feeding value and is most apt to be of even quality, corn being the main and sometimes the only grain used. The other grades vary in their composition in proportion to the relative amounts of corn, rye and oats used in the mashes; the more the corn and the less the smaller grains, the better the grade of the products. The higher grades only have thus far been found upon the Vermont markets, mostly guaranteed from 33 to 35 percent protein and 11 to 15 percent fat, but not often as a matter of fact making good their protein guaranties. No one of the desirable concentrates has sinned in this respect so consistently. This is however no certification of inferiority. They are as a class good goods whether up to or below guaranty.

BREWERS' DRIED GRAINS

These materials are being used more commonly in Vermont than formerly. They are simply dried residues of the process of beer brewing and consist mainly of barley grains from which have been removed the starch and soluble matter. Their protein content is not quite as high as that of the distillers' grains as a rule, but like them they are bulky in character and make an admirable diluent of the more concentrated feeds. They should be of a light color, possess a faint aromatic odor, and should be free from any material acidity. They should consist of the hull, germ and the gluten of the barley and comparatively small amounts of starch. Dark brown colored grains have either been injured before drying or heated to too high a temperature. These materials are extensively fed in Europe and in the West, and have proved to be an economical and satisfactory protein concentrate for cows and horses. They contain on the average 10 percent more protein than does bran, rather less carbohydrates, and about the same amount of total digestible nutrients. They are in no wise injurious.

FLAX FEED

This material has beeen found on sale on the Vermont markets for two years. It has been characterized in preceding bulletins of this station (see bulletins 133, 138). Two or three different brands have been found. Originally the material appeared to be composed mainly of broken flax seed, straw and many seeds or screenings (fox tail, pigweed, lady's thumb, poas, amaranth, kale, and other weeds not to speak of some timothy and small grasses). The only brand found upon sale last March has been altered in its physical character in that it has been very finely ground. Casual inspection does not indicate the presence of unground weed seeds.

PROPRIETARY DAIRY FEEDS (*other than molasses and oat feeds*).

Several of these materials are offered upon the Vermont market. They are usually composed of several standard feeding stuffs mixed in proportions making them well fitted for the purpose for which they are intended. The ingredients quite commonly used are such well known materials as cottonseed meal, linseed meal, hominy meal, gluten feed, wheat offals, etc., while either brewers' or distillers' grains are generally made the basis of the mixtures.

MOLASSES FEEDS.

The manufacture of molasses feeds began as an industry about twelve years ago. The demand has rapidly increased and today they are a prominent article of commerce. Many mills are turning out these products exclusively. It is stated of certain molasses feed factories that they have a capacity as high as 500 tons a day. There are several methods of compounding these feeds. Sometimes molasses is mixed with the absorbing materials without submitting any of them to heat; sometimes it is added to the kiln dried products; sometimes it is added hot to hot dried absorbents; and sometimes hot molasses is added to these products when in a cold condition. The more common procedure in the manufacture of the dry products usually sold on the New England markets is to add the hot molasses to the artificially dried absorbents. Most factories use a mixture of beet and cane molasses, the latter being particularly employed to give the product a pleasant aroma.

Many combinations of materials are used in the manufacture of molasses feeds. The choice is determined by such factors as location, demand, ease of obtaining the materials, cost of raw materials etc. Mr. J. E. Halligan, chemist of the Louisiana Experiment Station, in a recent article[1] from which much of of this matter is briefed, intimates that the following materials are used in the manufacture of molasses feeds:

"Cottonseed meal, malt sprouts, dried brewers' grains, distillery products, rice bran, rice polish, rice hulls, corn, corn chops, corn bran, ground corn-cobs, ground corn-stalks, corn pith, wheat products (generally wheat screenings), dried beet pulp, oats (generally off-grade oats), oat hulls, finely ground or chopped hay (usually leguminous hays, such as alfalfa), straw, flax brands (including all weeds, dust, dirt and screenings from the flax seed as well as part of the shell and fiber of the flax), elevator dust (including grain smut, all sorts of brushings, and cleanings, such as dust, grain rust, etc.), sweepings, grain screenings, refuse from flouring mills, cockle seeds, bran, ground peanut shells, weed-seeds (ground and unground), chaff from pipe factories and similar products." There are said to be many molasses feeds on the market composed of clean, standard products, but it well understood that there are likewise many wherein inferior materials such as rice middlings, weed seeds ground and unground, corn, elevator dust, grain screenings, ground straw, oat hulls, etc., are used as a filler with high protein concentrates as fortifiers. Mr. Halligan states that the composition of the products is sometimes changed from time to time according as the prices of the crude stock alter or as the opportunity of the manufacturer to obtain them is affected.

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[1] Jour. Ind. and Eng. Chem. I, 7 (July, 1909), pp. 441-445.

The amount of molasses employed varies from ten to sixty percent. Dried feeds such as are sold in the New England markets rarely carry over 25 percent molasses unless they have been subjected to a drying process after its use. Mr. Halligan gives the analyses of eleven dairy feeds and as many horse and mule feeds. He intimates that there is from 20 to 30 percent of beet molasses and from 5 to 10 percent of cane molasses used in making the dairy feeds, save in two brands in which from 15 to 30 percent of cane molasses is used. Roughly the same amounts are used in the horse brands.

The table on the opposite page adapted from his article shows the ingredients found in eleven dairy feeds and in eleven horse feeds. There is no reason to cavil at the presence of the materials listed above the cross line, although one perhaps may question very properly the advisability of buying chopped hay at concentrate prices. Per contra, there is no reason to look with anything but distrust upon the presence of any of the materials listed below the line. If the viability of the weed seeds or screenings is absolutely destroyed the doubt is in some degree resolved; yet even then there is question, since certain seeds common in this class of material, such as the corn cockle, have a poisonous effect upon stock.

PRODUCTS USED IN MOLASSES FEEDS. (ADAPTED FROM HALLIGAN)*

	In 11 dairy feeds.	In 11 horse feeds.
Cottonseed meal	9	8
Linseed meal	—	1
Malt sprouts	6	—
Distillers' grains	3	2
Brewers' grains	4	2
Wheat bran	—	1
Barley	1	1
Corn and corn products	6	3
Corn bran	1	—
Corn chop	—	6
Off grade oats	6	4
Off grade corn	3	—
Chopped alfalfa	—	5
Chopped hay (legume)	—	1
Weed seeds and wheat or barley screenings	7	4
Sweepings	—	1
Elevator dust	5	3
Oat hulls	5	2
Rice hulls	3	3
Rice polish	1	2
Flax screenings	1	1
Ground corn stalks	1	1
Ground corn cobs	1	1

Dairy feed number 7 in Halligan's list is said to be made up of brewers' grains, malt sprouts, cottonseed meal, and from 25 to 30 percent of cane molasses. This is the only one of eleven which appears to contain nothing to which exception might be taken from the standpoint of economics. Three of the horse and mule feeds contain only the better forms of concentrate and each of these contains either chopped alfalfa or legume hay. (No. 3, corn chops, wheat bran, cottonseed meal, alfalfa and 15 or 25 percent cane molasses; No. 4, corn chops, cottonseed meal, Lespediza hay (chopped) 20 percent cane molasses; No. 6, chopped alfalfa, corn, off grade oats, barley and about 25 percent beet molasses). The other eight all contain inferior products. A small amount of salt is a common ingredient in many of these molasses feeds, being used for the purpose of making them more palatable.

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*This table should be construed to read as follows: Cottonseed meal was a constituent of 9 of the 11 dairy molasses feeds and in 8 of the 11 horse molasses feeds.

The advisability of the purchase of a molasses feed depends of course upon its composition. There is no escape from the conclusion that as a class they are at present open to suspicion, owing to the large amounts of weed seeds, screenings, etc., hitherto employed in their manufacture. It would seem worth while for manufacturers to put out wholesome feeds made entirely from good materials and to advertise them as such, indicating what materials were used. One would think that such a procedure might pay. There seems reason to believe that molasses feeds as a class are improving. Certain it is that some concerns putting out the more grossly contaminated goods either have been forced out of business or have improved their formulas.

Recent experiments at the Massachusetts station[1] upon the feeding value of molasses have served to raise a pertinent question, viz., whether at ruling prices molasses feeds are as worthy of consideration as are more standard and more definite products. Molasses carries a very small amount of protein, and is a bulky feed; but it contains large amounts of digestible carbohydrates. Careful experiments in many countries have led to the general conclusion that molasses is not an economical food for cows, although perhaps desirable for horses. It may be advantageously employed for rendering inferior hay or fodder more palatable. The writer is convinced that quite apart from the danger of the introduction of weed seeds, the purchase of this class of material at ruling prices is uneconomical. Many farmers buy these goods reasoning that they must be desirable because the animals eat them readily. A child eats a box of candy costing eighty cents a pound and smacks its lips; but it does not follow that on that account the purchase was either advisable, dietetically desirable, or economical. Molasses tempts the appetite of both four and two-legged creation; molasses *per se* may be worth considering; but molasses plus weed seeds *et al* should be anathema.

HOMINY MEAL. CHOP FEED

This diversely named material is a by-product of hominy mills and of distilleries. It is usually obtained from white corn and carries about the same amounts and proportions of nutrients other than fat that are contained in ordinary corn meal.

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[1] Mass. Exp. Sta. Bul. 118 (1907).

CORN AND OAT FEEDS. OAT FEEDS

These products of the oatmeal industry have been sold on Vermont markets for years, but do not seem to enjoy as large sales today as formerly. There appear to be two classes of these feeds. One seems made up of varying proportions of broken corn and oat residues, with more or less middlings and frequently high grade concentrates used to increase the protein content, together with a little salt. The other appears to consist of hominy, rye, oats and oat residues, with perhaps middlings and salt. As a class they are an expensive form of feed. What well informed dairy feeder would pay $31, the average price of these goods this year, for feed averaging but 9 percent protein and 5 percent fat, when for $32, cottonseed meal carrying 41 percent protein and 9 percent fat is obtainable, and when for less than $30 one can buy brewers' grains carrying as a class thrice as much protein? Moreover, provenders, strictly such, sold but for $2 a ton more did than these goods. Further comment seems unnecessary.

WHEAT OFFALS

These materials are the well known and standard by-products obtained in the manufacture of wheat flour. The outer layers of the kernel, relatively dark in hue and not easily pulverized, constitute the bran; the inner layers of its covering, lighter in hue and more easily pulverized together with other portions of the kernel from which the finer grades of white flour cannot be made, make up the middlings; while the Red Dog flour, so-called, is simply a dark feeding flour not adapted to the making of higher grades for human consumption but actually the richest of the by-products in protein. The so-called mixed feed is simply the brans and middlings run together, often with other waste wheat products. It is not at all uncommon for manufacturers to run their screenings either ground or unground into their mixed feeds, although of late there has been so large a call for these products in the manufacture and sophistication of other feeds that the wheat products are less apt than formerly to be loaded with them.

The feed laws of several states now require that guaranties be placed upon wheat offals; hence many of those found on Vermont markets are guarantied as to their composition, a condition which has only recently obtained. Occasionally mixed feeds are found with which are admixed more or less ground corn cobs or similar material. These goods can be legally sold only when they carry a tag proclaiming the presence and nature of the adulterant.

ALFALFA MEALS

Ground alfalfa meal, so-called, has been offered for sale on New England markets for the last year or two. It is simply a finely ground alfalfa hay. Sometimes the coarser stalks are rejected; sometimes not. While alfalfa is well worth growing as a roughage and while a successful crop tends to emancipate the feeder from the necessity of purchasing large amounts of concentrates, it does not follow that it is a part of wisdom to buy ground alfalfa meal in lieu of such concentrates and at practically concentrate prices. It is in the writer's judgment a highly expensive purchase for Vermont farmers.

POULTRY FEEDS

Many proprietary poultry feeds and mashes are found upon the market. Some of these are highly concentrated, such as the beef scraps, and some, like the scratching grains, are composed simply of broken grain products. The prices asked for these feeds are apt to be relatively high as compared with the original costs of the materials from which they are made.

V. The Economics of Feed Purchase

THE RELATIVE COST OF FEEDS

In order to state the economics of feed purchase in a manner admitting of ready comprehension the following tables have been prepared in which are shown the protein content and the average cost of each feed, the pounds of protein furnished for a dollar, and the cost of a pound of protein. The different digestibilities of the sundry feeds may be in most cases ignored, for the reason that the digestion coefficients of these several feeds, excepting those containing relatively high percentage of fiber, are apt to vary within such comparatively narrow limits. The lower grade goods, such as molasses and oat feeds carrying high amounts of fiber, as a rule are relatively less digestible.

It should be remembered, of course, that the figures in these tables represent the average selling prices of the year of 1908-09, high water mark to date in feed costs. Moreover that the data are the more apt to be truly valid in proportion to the numbers of samples of the various feeds. To call a feed by a definite name does not insure its protein grading, for the reason that feeds bearing the same name often vary widely. Cottonseed meals may legitimately range from 36 or 37 to 43 percent protein; gluten feeds from 21 or 22 to 25 or more percent protein. It is on this account therefore that these tables simply afford general information. To make them thoroughly applicable to local conditions one should compare the guaranties, analyses and selling prices of the particular feeds he has in hand.

	Samples.	Average protein content.	Average ton cost.	Pounds of protein for a dollar.	Cost of a pound of protein.
Cottonseed meal	11	40.4	$32.25	25.1	4.0 cts.
Linseed meal, new process..	2	38.7	34.25	22.6	4.4
Linseed meal, old process..	3	37.1	35.00	21.2	4.7
Distillers' dried grains	4	29.6	33.50	17.7	5.6
Proprietary ready rations..	4	27.4	32.75	16.7	6.0
Brewers' dried grains	2	26.7	29.50	18.0	5.6
Gluten feeds	5	25.6	32.50	15.8	6.4
Cottonseed feed	2	23.2	30.00	15.5	6.4
Red dog flour	4	18.1	33.75	10.7	9.3
Wheat middlings	21	17.	32.50	10.5	9.5
Wheat mixed feed	34	16.2	31.25	10.4	9.6
Wheat bran	25	15.8	29.00	10.9	9.0
Molasses feeds	7	16.5	29.25	11.3	8.9
Flax feed	1	16.2	27.00	12.0	8.3
Alfalfa	2	16.0	30.00	10.7	9.3
Provender	5	9.9	33.00	6.0	16.7
Hominy	3	9.7	30.00	6.5	15.4
Oat feeds, corn and oat feeds	7	9.6	31.00	6.2	16.1

Goods carrying	Furnished for a dollar, pounds protein	Cost of pound of protein	Cost per ton.
More than 30% protein....	23	4.4 cts.	$34.00
From 25 to 30% protein....	17	5.9	32.00
From 20 to 25 % protein....	15½	6.4	30.00
From 15 to 20% protein....	11	9.1	30.50
Less than 10% protein.....	6½	16.1	31.50

The most cursory view of these tables indicates that the retail price of a feed affords no necessary measure of its value in respect to the amount of protein contained. Feeds that are low in protein require the addition of some more proteinous material in just the same manner as would be the case with a farm grown roughage. There are plenty of feeds on sale on Vermont markets which carry but little more protein, and in some cases but little more total nutrients, than do the ordinary farm roughages; and those who buy them are buying no more nutrients than would be contained in an equal amount of hay or other roughage. These feeds, low in protein, doubtless are worthy of consideration by a city feeder of horses or of one who stall feeds cattle, by parties who must buy all of their feeding stuffs, roughages and concentrates alike and can grow none; but for the Vermont dairy farmer to buy such for his cattle is folly. It is not cheap and gaudy lithographs, nor attractively stencilled feed sacks, nor speciously worded advertisements, nor glowing testimonials, nor is it the say so of the feed dealer whose profits are apt to be relatively high on the low grade feeds and relatively low on high grade feeds; it is none of these things which cause a cow to give milk, but it is the nutrients which are contained in her ration, it is the intrinsic feeding value of the purchased material, the dominants of which for this purpose are, first its protein content, and second its digestible dry matter content.

It does not follow of course that the feed which furnishes the most protein for a dollar should be used to the exclusion of other feeds. Other considerations than simply the protein content enter into the problem; but that such should never be overlooked in ration formulation is a safe proposition to advocate.

VI. THE FORMULATION OF GRAIN RATIONS

The Station is often asked "What is the best grain ration?" for cattle or for horses. The writer does not recollect a single request for a good ration. The best one is always sought, but never vouchsafed, for there is no best; nor will there ever be such. There are plenty of good ones, some better than others, some to be preferred over others when the market is thus and so, but not to be preferred when it is otherwise. Thus for example, bran at $20 a ton should be freely used, while at $30 it is a luxury. Yet on the other hand it is difficult to get along without it and even at the higher price must often needs be used although perhaps in smaller quantities than when it is cheaper.

To be thoroughly acceptable a ration should be:

1. Bulky, measuring more in quarts than it weighs in pounds, because heavy rations are relatively indigestible.

2. Palatable and free from mold or other deterioration due to imperfect storage.

3. Proteinous to the extent of 16 or more pounds *digestible* protein per hundred. It should be noted that this dictum calls for *digestible* not *total* protein.

4. Sufficiently digestible to carry 60, or, better, 65 pounds of digestible dry matter per hundred.

5. Capable of furnishing at present high prices a 7 pound ration at a cost not to exceed 11 cents.

The following rations are suggested which ought to prove fairly satisfactory for the purposes mentioned. The figures shown do not indicate the amounts which should be fed, but prescribe the proportions by weight, not by measure, of the sundry feeds to be employed. The table on page 44 indicating the relationships between weights and measures of various feeds may be serviceable in the determination of the mixing, as may also the table on page 43 showing the approximate value of 7 pounds of each of these mixtures. The amounts to be fed will naturally vary according to local circumstances, the character and extent of roughages available, the type of animal used, if cows whether new in milk or strippers, etc. In short, judgment must be used in the employment of these rations as to the amount which it is desirable to feed. The order of statement has no meaning. The writer expresses no preference for any one of these rations, each of which he deems worthy of use. Economic considerations will naturally govern the feeder in his choice. Furthermore and finally it should be said that a multitude of other combinations quite as serviceable may be made, as well as myriads quite unadapted to this purpose.

The tables indicate 18 mixtures for dairy cows, a few for horses, and a few for poultry. The horse and poultry formulas are taken with slight modification from bulletin 220 of the New Jersey station; and numbers 7 to 13 of the dairy rations are with slight modifications taken from bulletin 112 of the Massachusetts station.

FOR DAIRY FEEDING

		Pounds
I.	Dried distillers' or brewers' grains	4
	Wheat bran	3
	Cottonseed meal	2
II.	Wheat bran	5
	Cottonseed meal	1½
	Linseed meal	1½
III.	Dried distillers' or brewers' grains	3
	Wheat bran	2
	Cottonseed meal	1½
	Linseed meal	1½
IV.	Gluten feed	1
	Dried distillers' or brewers' grains	1
	Cottonseed meal	1
V.*	Gluten feed	2
	Corn meal or hominy meal	2
	Dried distillers' or brewers' grains	4
	Cottonseed meal	1
VI.	Wheat mixed feed	2
	Gluten feed	1½
VII.	Wheat bran	3
	Gluten feed	3
	Cottonseed meal	1
VIII.*	Wheat bran	5
	Cottonseed or linseed meal	4
	Corn meal or hominy meal	5

IX.	Wheat bran	3
	Gluten feed	4
X.	Distillers' or brewers' dried grains	3
	Wheat bran	1
	Cottonseed meal	1
XI.	Distillers' or brewers' dried grains	4
	Wheat middlings	3
XII.*	Distillers' or brewers' dried grains	3
	Corn meal or hominy meal	2
	Gluten feed	2
XIII.*	Distillers' or brewers' dried grains	4
	Corn meal or hominy meal	2
	Cottonseed meal	1
XIV.*	Wheat bran	4
	Corn meal or hominy meal	4
	Linseed meal	2
XV.	Distillers' or brewers' dried grains	4
	Wheat bran	3
	Corn and cob meal	2
	Cottonseed meal	1½
XVI.*	Distillers' or brewers' dried grains	4
	Gluten feed	4
	Corn or hominy meal	2
	Linseed meal	1
XVII.*	Corn meal or hominy meal	3
	Wheat bran	4
	Cottonseed meal	2
XVIII.*	Dried distillers' or brewers' grains	3
	Wheat bran	4
	Corn meal or hominy meal	1
	Linseed meal	1

FOR WORK HORSES.—TO BE FED WITH ABOUT 10 POUNDS OF HAY

I.	Corn	6 or 6
	Wheat bran	5 or 4
	Linseed meal	1½ or 1
II.	Distillers' or brewers' dried grains	1
	Corn	1
	Oats	1
III.	Distillers' or brewers' dried grains	1
	Corn	1

---

*These should be used only when well-eared corn fodder or silage is lacking or scanty.

FOR POULTRY

Dry mash.

I.	Wheat bran	2
	Corn meal	1
	Linseed meal	1
	Gluten feed	1
	Wheat middlings	1
	Beef scraps	1
II.	Wheat bran	3
	Wheat middlings	4
	Corn meal	4
	Beef scraps	1

Scratching feed.

III.	Cracked corn	4
	Wheat	4
	Barley	1
	Oats	1
	Buckwheat	1½
IV.	Cracked corn	4
	Corn	1
	Wheat	1
	Barley	4
	Oyster shells	1
V.	Cracked corn	2
	Wheat	2
	Barley	2
	Buckwheat	2
	Sunflower	1

On page 43 will be found a table indicating the cost per 100 pounds of each mixture, the pounds of digestible dry matter and of digestible protein in 100 pounds of each mixture, the cost of a pound of digestible dry matter and of a pound of digestible protein (it being assumed in each case that the entire money is spent for digestible dry matter in the one case or for digestible protein in the other case, an assumption the latter portion of which of course is open to question), the cost of a 7 pound ration and the approximate measure by volume of a 7 pound ration.

This latter table is based so far as it relates to money matters upon the ruling prices for the feeds that were employed in the formulas as found on sale in the Vermont markets in December, 1908, and March, 1909. These prices were approximately:

Cottonseed meal, $32.25; linseed meal, $34.75; gluten feed, $32.50; distillers' dried grains, $33.50; brewers' dried grains, $29.50; wheat bran, $29; middlings, $32.50; wheat mixed feed, $31.25; red dog flour, $33.75; corn meal, $29; hominy feed, $30.

The ruling prices at the same time of other feeding stuffs were as follows:

Molasses feeds (as a class), $29.25; alfalfa, $30; corn and oat feeds (proprietary), $31; provenders (strictly such), $33; rye middlings, $29; flax feed, $27; proprietary ready rations, $32.75; poultry feeds, $38.

These prices are of course in some cases extraordinarily altitudinous. It is to be hoped that they represent high water mark is feed prices. This fact makes the cost data very high, but serves perhaps to illustrate the more clearly the folly of buying low grade materials.

The question may be asked why some of the articles above mentioned are not included in the formulas. The reasons for their exclusion from these suggested rations are as follows:

Molasses feeds as a class. Because as a class these goods furnish relatively costly digestible dry matter and relatively costly digestible protein, and because as a class they are still under suspicion in the matter of weed seeds with which, up to very recent times, they have been heavily loaded. (See pages 28-32).

Alfalfa meal. This material furnishes digestible dry matter and protein at a relatively high price. It contains a little more protein probably than does a high grade clover hay. To pay $30 a ton for clover hay would be thought insanity. (See page 34).

Corn and oat feeds. For the reason that this class of material as is well known carries extraneous oat hulls and tends to be low in protein. It furnishes very costly digestible dry matter and digestible protein. (See page 33).

Provender. To feed this material to cows at present prices of corn and oats when it carries but 10 percent protein is obviously unwise. The material may very properly be used for horses and could enter into formula ii in place of straight corn and oats.

Rye middlings, are not indicated for feeding cattle for the reason that there is likelihood that they may cause ergotism and consequent abortion if they are freely fed.

Flax feed has been a highly undesirable material even at a bottom price. Up to the last inspection this class of goods has consisted mainly of unground seeds, a large share of which were of weed types and were viable. The jobber of the only brand now found upon Vermont markets claims at present to be putting out a material, the seed content of which is entirely ground.

Poultry feeds. These are not indicated for the reason that they are proprietary mixtures and the propriety of publicly advising this, that or the other proprietary mixture is open to question.

Proprietary rations. These are materials placed upon the market as complete mixtures and obviously do not adapt themselves to the making of a mixture.

It may be noticed that the wheat mixed feeds are but rarely suggested. The writer feels that this material is more open to sophistication than are either bran or middlings and that this adulteration is more readily overlooked. It consists of bran and middlings together with other less important wheat offals and sometimes includes screenings. He sees nothing at present prices to commend mixed feeds as compared with the separates.

Corn meal and hominy feed are suggested only in cases where the home grown corn supply, either as corn fodder or as corn silage, is scanty. For the buyer to pay $29 and $30 for this material if he has a sufficient amount of corn at home is to take coals to Newcastle.

	ONE HUNDRED POUNDS			ONE POUND OF		A SEVEN POUND RATION	
		contains					
		diges-tible dry matter.	diges-tible pro-tein.	diges-tible dry matter	diges-tible pro-tein		measures about
	costs	lbs	lbs	costs	costs	costs	Quarts
Dairy							
I,	$1.56	62	21	2.5 cts.	7.4 cts.	10.9 cts.	11+
II,	1.56	60	22	2.6	7.1	10.9	11
III,	1.59	66	25	2.4	6.4	11.1	10
IV,	1.60	70	25	2.3	6.4	11.2	7+
V,	1.56	71	19	2.2	8.2	10.9	8
VI,	1.58	69	16	2.3	10.0	11.1	9
VII,	1.57	67	18	2.3	8.6	11.	9—
VIII,	1.54	68	17	2.3	9.1	10.8	8.5
IX,	1.57	68	16	2.3	9.8	11.	9—
X,	1.56	64	22	2.4	7.2	10.9	11
XI,	1.58	65	17	2.4	9.3	11.1	10—
XII,	1.56	73	17	2.1	9.2	10.9	8
XIII,	1.54	69	19	2.2	8.9	10.8	9
XIV,	1.54	66	14	2.3	11.4	10.8	9
XV,	1.53	65	19	2.4	8.0	10.7	11
XVI,	1.59	73	19	2.2	8.4	11.1	8—
XVII,	1.51	66	15	2.3	10.1	10.6	9—
XVIII,	1.54	63	16	2.4	9.6	10.8	11.5
Horse.							
I,	1.50	67	12	2.3	12.5	10.5	8.5
Ia,	1.49	68	11	2.2	13.6	10.4	8
II,	1.67	68	12	2.5	13.9	11.7	7.5
III,	1.51	71	14	2.1	10.8	10.6	8
Poultry.							
I,	1.69	67	20	2.5	8.5	11.9	8
II,	1.59	67	13	2.4	12.0	11.1	9—
III,	1.87	74	8	2.6	24.0	13.1	4+
IV,	2.03	85	8	2.4	25.4	14.2	4+
V,	2.11	72	8	2.9	26.4	14.8	4.5

THE WEIGHT OF ONE QUART OF SUNDRY FEEDING STUFFS

The following table shows the approximate weight of one quart of each feed named. It will be found useful in the calculation of the weight of grain rations, in view of the fact that measurement by volume is almost universally used on farms. It is compiled from tables published by the Connecticut (State) and Massachusetts stations.

A quart of	Weighs
Cottonseed meal	1.5 lbs.
Linseed meal, old process	1.1
Linseed meal, new process	0.9
Gluten feed	1.3-1.4
Distillers' dried grains	0.5-0.7
Brewers' dried grains	0.6
Malt sprouts	0.6
Wheat bran, coarse	0.5
Wheat middlings, coarse	0.8
Wheat middlings, fine	1.1-1.2
Mixed wheat feed	0.6
Corn meal	1.5
Corn (whole)	1.7
Corn and cob meal	1.4
Corn bran	0.5
Hominy meal	1.1-1.3
Provender	1.5
Oats (whole)	1.0-1.2
Oats (ground)	0.7
Alfalfa meal	1.0
Molasses feed	1.1
Oat feed	0.7-1.0

VII. CONCERNING FEEDING

THE COMPOSITION OF FEEDS

Feeds contain: water, ash, protein, crude fiber, nitrogen free extract and fat.

The *water* in feeds is simply that natural moisture which is found in almost all materials. However dry a feed may appear to be, it always contains more or less moisture even though it can neither be seen nor felt. Its amount is constantly changing according to climatic conditions, the moisture content of the air, the kind of feed, its age, method of storage, etc., and may and does vary sometimes to the extent of a percent or two from day to day.

The *ash* is the mineral matter of the grain and consists mainly of lime, potash, magnesia, phosphoric and other acids. From it the skeleton structure of animal life is constructed and repaired and the mineral matter necessary to tissue maintenance supplied. While some feeding stuffs are notably lacking in ash, few rations of roughage and concentrates fail to furnish a sufficient quantity, save that salt and sometimes lime need be added.

Protein is a term applied to the nitrogenous constituents of a feed and includes such materials as the gluten of wheat, the lean part of beef, the white of an egg, etc. It is a general and approximate expression for these flesh forming nutrients which contain nitrogen as their peculiar and essential constituent, and which perform the important function of constructing and repairing muscular tissues. It is the most expensive nutrient, and that least easily produced upon the farm. On that account and for almost all purposes for which such materials are bought, those grains and by-products containing the most protein are the better purchases. Protein contains ordinarily about 16 percent of nitrogen, and the common way of estimating it in the laboratory is to determine the nitrogen content and multiply the same by 6.25.

The *crude fiber* is the structural material of the vegetable cell wall, the woody part of grain, hay, etc. Cotton and linen are nearly pure fibers. It is the most insoluble portion of vegetable matter and of minor value for feeding purposes.

The *nitrogen free extract* or carbohydrates include such materials as starch, the sugars, gums, etc., materials of a non-nitrogenous nature, "nitrogen free" and extractable by water and dilute acids. Their particular service is not to build tissue but to furnish fuel for combustion in the body for the maintenance of animal heat, for the furnishment of the energy needed for the proper performance of the bodily functions, and for the production of work.

Fat, or ether extract as it is better called, consists of the fats, oils, waxes, chlorophyll and other coloring matters which are extracted by means of ether. The function of this complex substance is practically the same as that of the nitrogen-free extract, although its digestible portion has from 2.25 to 2.4 times the heat producing power of the digestible nitrogen-free extract.

The properly fed domestic animal consumes roughage largely and concentrates less freely. Roughages carry relatively high proportions of carbohydrate, are relatively low in protein, and those nutrients are less digestible than are the similar ones in concentrates. Per contra, the grains and by-products as compared with the roughages carry as a rule relatively high proportions of digestible carbohydrates, usually more digestible protein, always less fiber, and the nutrients as a whole are much more digestible. These points are well illustrated by a few figures drawn from bulletin 81:

	DIGESTIBLE NUTRIENTS.			
	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
Mixed hay carries........	4.4	16.3	24.8	1.2
Timothy hay carries	2.8	15.4	27.9	1.3
Corn fodder carries	2.5	8.	25.	1.2
Corn stover carries	1.4	12.7	18.4	4.8
Corn silage carries	1.2	4.6	11.5	0.7
Corn meal carries	6.3		65.3	3.5
Cottonseed meal carries...	40.*	3.1	13.8	10.4*
Gluten feed carries	20.3	5.1	50.4	2.9

The functions of the digestible nutrients in concentrates are more particularly:

To increase the total digestible dry matter of the ration without materially augmenting its bulk.

To increase the digestible protein content of the ration.

To furnish nutrients which will digest with a minimum expenditure of bodily energy.

Roughages furnish digestible nutrients but not in compact form. Their nature does not admit of a high degree of digestibility, and their protein content is relatively low. A ration made up entirely of oat straw carries plenty of dry matter, but little digestible dry matter. The alimentary canal of the animal must exert itself to such an extent, that the gain from the digested material is not equivalent to the usage of energy (which means food hitherto digested) needed to assimilate it. In short it costs more to run the machine than is gained. Then, too, the protein content of straw is almost nullity. What has been said as to straw holds to a less degree for roughages in general; and hence it is that concentrates carrying large amounts of easily digested protein are employed.

---

*At the time of writing bulletin 81, (1900) cottonseed meal carried much more protein and ether extract than it does today.

An animal needs at least a definite amount of definite nutrients to enable it to do its work, just as a boiler needs a definite amount of fuel to enable it to make steam. These food nutrients must be of several kinds, ash, protein, carbohydrates, fat, as indicated on pages 44 and 45. A shortage of any one means an unbalanced raation and a wastage, both actual and potential. Altogether too often the wrong crops are grown and the wrong concentrates purchased, because their composition and the functions of the nutrients they contain are not clearly apprehended. It is difficult to grow in New England a sufficient supply of protein adequately to meet the needs of the dairy cow, and at the same time economically to make use of the carbohydrates which are readily grown. The corn and hay crops are the most economical sources of farm grown carbohydrates, while in order to acquire home grown protein, in part to meet animal needs, recourse must be had to legumes.

HOME GROWN PROTEINS

Concerning these it may be said:

Alfalfa is an uncertain crop in New England. A few farmers have grown it successfully in the Champlain valley and elsewhere, but the majority who have tried it have failed. (See bulletins 114 and 129 on alfalfa growing in Vermont; also bulletin 305 of the New York (Geneva) station on "Alfalfa Troubles"; also Farmers' Bulletin 339 of the United States Department of Agriculture at Washington, D. C., on "Alfalfa").

Clover is a biennial, possibly a short lived perennial, which is best grown in rotation. It is much the most certain source of home grown protein in New England. It may be used as a soiling crop, or may be hayed or ensiled, the latter preferably as rowan with corn. It is not a costly crop to grow, betters the mechanical condition of the soil, adds to its nitrogen content, tends to translocate mineral plant food from lower to higher soil levels, produces considerable amounts of digestible protein, makes an admirable hay, and is well adapted to the climatic conditions of Northern New England.

Peas and oats form a satisfactory soiling crop and furnish more protein than do oats alone. Peas grown alone for threshing have succeeded well in Canada and have been found satisfactory by some Vermont growers.

Soy beans (preferably the medium green variety), when grown, and cultivated in the same row with corn and ensiled therewith, have approved themselves to certain Vermont dairymen. The crop may be grown by itself, separately harvested, and run into the silo with the corn, but this is a more costly procedure than that just indicated and its desirability is doubtful as compared with growing them in the same row with the corn. The crop furnishes more digestible protein than does corn, but less digestible dry matter. The mixed corn and soy bean silage makes a satisfactory feed.

It is generally held that a milch cow needs from 21 to 24 pounds of total dry matter; from 2 to 2½ pounds digestible protein; and about 13 pounds of digestible carbohydrates and fat daily. To secure this amount of protein from roughage alone would necessitate that she eat daily 55 pounds of medium hay, or 90 pounds of timothy hay, or 100 pounds of corn fodder, or 175 pounds of corn stover, or 200 pounds of corn silage. The carbohydrates, however, would be furnished by moderate amounts of these roughages. Obviously in order to get enough protein she must eat concentrates. A ration of 12½ pounds of mixed hay, 20 pounds of silage, and 7 pounds of ration 2 as indicated on page 40 would furnish approximately 23 pounds of total dry matter, 2½ pounds of digestible protein and between 12½ and 13 pounds of digestible carbohydrates and fat. One might use corn meal, or corn meal and bran, or oat feeds indefinitely and not attain this end save by the use of many more pounds of grain feed (20 pounds or upwards); and then in gaining the needed protein the total dry matter and carbohydrate requirements would be immensely overmet.

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BURLINGTON, VT.

BULLETIN NO. 145

OCTOBER, 1909

Vermont Shrubs and Woody Vines

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 145: VERMONT SHRUBS AND WOODY VINES

By L. R. Jones and F. V. Rand[1]

ILLUSTRATED BY MARY ROBINSON

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[1] The account of the Rose family was largely prepared by Mr. W. W. Eggleston, who also read the entire manuscript and made helpful suggestions at numerous points. Use has also been made of the data accumulated by Mr. Harmon Sheldon, of the class of 1907 of the University of Vermont, whose senior thesis was upon Vermont Shrubs. The authors make grateful acknowledgement of their indebtedness to these gentlemen.

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INTRODUCTION

It is now just ten years since this station issued bulletin 73, The Trees of Vermont. Three years later bulletin 94 appeared on Vermont Grasses and Clovers. The present publication is the third in the series having a like general aim. It includes an account of the native shrubs and woody vines, with briefer mention of such introduced species as are of especial interest. Like the earlier publications it is primarily addressed to readers who have little or no botanical training, but who wish to learn the names of these plants as well as the main facts relative to their occurrence and characters. In this connection especial attention has been given to any matters of human relation such as edible qualities, poisonous nature, ornamental values, etc. In numerous cases pains has been taken to record facts concerning the use of these plants made by the Indians or the early settlers, for such purposes as dyeing and basketry. These things are of sufficient historical and educational worth to justify the space thus given to them; but, in addition, it seems probable that the revival of interest in the handicrafts, which is coming with industrial education, is prophetic of a return to the usage of some of these things. Certainly it is a wholesome thing for all of us to be reminded of such matters of early woodcraft.

This bulletin does not bear so directly as have the earlier ones of the series upon problems of practical agriculture and forestry, although it is clearly pertinent to such problems. It is the needs of the boys and girls of Vermont farms and villages and of their teachers in the rural schools that have been uppermost in mind in the preparation of these pages. Every such school ground has a natural setting of shrubs and vines; every roadside leading to it is fringed with natural growths that rival in aesthetic charm the finest plantations of the city parks. It is pitiful to realize that for the children educated in this environment the names and values of these things are a sealed book. What are we to say of progress in our educational methods when the school boy, yes and his teacher too, have not only less knowledge about these matters, but what is more lamentable less intelligent interest in them, than did his grandparents or even the Indian boy who once played in these same valleys. Quite apart from any mere practical applications of the information to human problems it is worth while to make any contribution possible to a change of attitude toward nature study, and one of the most important advance steps toward this goal will be made when each questioner realizes that there is within his reach the means of securing reliable answers to his inquiries. With this in view keys have been prepared with so little reference to the more obscure or minute botanical characters that it is hoped careful observers may identify an unknown plant.

The method of using the "keys" will probably be evident to most; yet lest any reader should be puzzled, an explanation of their use is given at the bottom of the next page. The matter of discriminating between related species has been simplified and the pages made clearer as well as more attractive by illustrations.

In the arrangement of families and the choice of botanical names, the usage of the Gray New Manual of Botany is followed. Where the names of earlier standard works or of other modern texts, including the Britton Manual, differ from this, the synonymy is entered in parentheses. For many of the English names the usage of the Britton Manual has been followed, and where local custom departs from that of the botanical texts the aim has been to recognize it.

Our associates in the preparation of this bulletin, Mr. Rand and Miss Robinson, worked upon the details during their Junior and Senior years as the students at this University. It is but justice not only to acknowledge their conscientious collaboration but also to record the fact that this was largely a labor of love inspired primarily by their interest in the work, the satisfactory completion of which is their chief recompense. The writer wishes here to record his own appreciation of their assistance as well as that of Dr. Ezra Brainerd, who has advised in the treatment of the blackberry group and read proofs, and of Mr. W. W. Eggleston, who has made suggestions throughout and written much of the chapter on the difficult rose family.

L. R. JONES.

KEY FOR DETERMINING VERMONT SHRUBS AND WOODY VINES[1]

PREPARED BY F. V. RAND

1. Vines, i. e. stems climbing, creeping or trailing; not self-supporting 2
1. Shrubs, i. e. stems erect or reclining 11

2. Climbing over some support 3
2. Stems trailing or creeping on the ground 7

3. Climbing by twining stems 4
3. Climbing by tendrils situated opposite the leaves.......... 6
3. Climbing by roots produced wherever the stem touches a proper support ....Poison Ivy, p. 128
3. Climbing by leaf-stalks clasping support....Virgin's Bower, p. 80
3. Climbing by simply growing over the support. Climbing Nightshade, Solanum, p. 147

4. Leaves opposite, i. e. 2 at each joint or node of the stem. Glaucous Honeysuckle, p. 180
4. Leaves alternate, i. e. one at each joint or node 5

5. Leaves pinnately veined, margins toothed. Bittersweet, Celastrus, p. 132
5. Leaves palmately veined, lobed, with margins otherwise entire ....Moonseed Vine, 83

6. Leaves simple ....Grape, p. 137
6. Leaves compound ....Virginia Creeper, p. 140

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[1] Since the method of using a "key" like the above may not be clear to all, a word of explanation is added. Its purpose is to aid in determining the name of any strange Vermont shrub or woody vine. Suppose the unknown plant before you is a woody vine as characterized in the first line under "1" at the head of the "key"; you should then pass down to "2." Next note its habit; if its stems tend to climb over the support rather than to trail or creep on the ground you should pass on to "3" below. Here you must decide between the five types described. Suppose it climbs by roots produced wherever the stem touches a proper support such as the bark of a tree, you have the Poison Ivy and should turn to p. 128, for fuller description. If, however, it climbs by the leaf-stalks clasping the support, it is the Virgin's Bower and is described on p. 80. If, on the other hand it has tendrils, you must pass on to "6," where, according to character of leaf, you learn that your vine is either a Wild Grape or a Virginia Creeper.

7. **Leaves simple, evergreen** 8
7. **Leaves compound** ....Dewberry, p. 111

8. **Leaves saw-toothed, teeth bristle-tipped, aromatic.**
Wintergreen, p. 153
8. **Leaves not as above** 9

9. **Leaves with margin distinctly revolute, i. e. rolled backward.** 10
9. **Leaves with margin not revolute**......Arbutus, Mayflower, p. 166

10. **Fruit aromatic, white** ....Creeping Snowberry, p. 155
10. **Fruit not as above** 11

11. **Leaves linear-oblong; fruit black**.......Black Crowberry, p. 124
11. **Leaves oval, ovate, or obovate; fruit reddish**....Cranberry, p. 163

12. **Reclining shrubs** 13
12. **Erect shrubs** 15

13. **Leaves deciduous** ....Mountain Currant, p. 90
13. **Leaves evergreen** 14

14. **Leaves scale-like or awl-shaped** ....Juniper, p. 64
14. **Leaves not as above** ....Bearberry, p. 153

15. **Leaves evergreen or persistent** 16
15. **Leaves deciduous** 23

16. **Leaves 1-12 inch long** ....Hudsonia, Beach Heather, p. 141
16. **Leaves much more than 1-12 inch long** 17

17. **Leaves not over 1-12 inch broad** 18
17. **Leaves much over 1-12 inch broad** 12

18. **Leaves awl-shaped, needle-pointed; mature fruit a bluish berry** ....Juniper, p. 63
18. **Leaves flattened, not sharp, borne in a hemlock-like spray; mature fruit a red berry**........Ground Hemlock, Yew, p. 65

19. **Leaves densely brown-woolly below**.........Labrador Tea, p. 170
19. **Leaves not as above** 20

20. **Flowers in a long one-sided spray**............Leatherleaf, p. 166
20. **Flowers not as above** 21

21. **Fruit-pod (capsule) distinctly oblong; flowers large and showy, 1½ to 2 inches across**.......Great Rhododendron, p. 171
21. **Fruit-pod (capsule) globular or nearly so; flowers smaller**.... 22

22. Buds naked; flowers showy, purple or pink; corolla ½ to 1 inch across ....Smaller Laurels, Kalmia, p. 169

22. Buds scaly; flowers rather inconspicuous, white; corolla not over ¼ inch across.........Wild Rosemary, Andromeda, p. 165

23. Leaves simple 31

23. Leaves compound 24

24. Leaves opposite 25

24. Leaves alternate 26

25. Fruit (capsule) having 3 large inflated cells...Bladder-nut, p. 134

25. Fruit a berry ....Common Elder, p. 184

26. Leaves without stipules; flowers small, greenish..Sumach, p. 124

26. Leaves with stipules 27

27. Small, greenish flowers in early spring before the leaves; leaves and bark pungent-aromatic ....Prickly Ash, p. 123

27. Flowers, yellow or pink in early summer; plants not aromatic 28

28. Fruit edible ....Blackberry and Raspberry, p. 104

28. Fruits not edible 29

29. Flowers large, pink ....Rose, p. 114

29. Flowers small, yellow or white 30

30. Flowers in pyramidal clusters............Siberian Spiraea, p. 95

30. Flowers not as above ....Cinquefoil, Potentilla, p. 101

31. Leaves opposite or whorled, i. e. two or more at each joint or node of the stem 32

31. Leaves alternate, i. e. only one at each joint or node 39

32. Fruit dry 33

32. Fruit pulpy 35

33. Flower and fruit in a dense, perfectly spherical head. Button-bush, p. 176

33. Flower and fruit not as above 34

34. Flowers in a long pyramidal cluster................Lilac, p. 173

34. Flowers not as above........Bush Honeysuckle, Diervilla, p. 177

35. Young shoots and under side of leaves brown-scurfy. Buffalo-berry, p. 143

35. Leaves and shoots not as above 36

36. Fruit with a single stone 37

36. Fruit with two or more seeds 38

37. **Fruit with a more or less flattened stone; flowers 5-parted. Viburnum, p. 187**
37. **Fruit with a globular or ovoid, two-seeded stone; flowers 4-parted .... Dogwood, p. 144**

38. **Berry snow-white with two seeds .... Snowberry, p. 178**
38. **Berry reddish or bluish-black with several seeds. Honeysuckle, Lonicera, p. 177**

39. **Leaves palmately-veined 40**
39. **Leaves pinnately-veined 41**

40. **Flowers large, pink; fruit thimble-shaped. Flowering Raspberry, p. 104**
40. **Flowers small, yellow, green or purple; fruit globose. Currant, Gooseberry, p. 87-89**

41. **Leaves lobed, fragrant .... Sweet Fern, p. 66**
41. **Leaves entire or toothed 42**

42. **Leaves sharply spiny-toothed .... Barberry, p. 82**
42. **Leaves not spiny-toothed 43**

43. **Branches armed with sharp thorns .... Thorn-apple, p. 118**
43. **Branches not as above 44**

44. **Leaves and bark strongly aromatic when crushed. Spice-bush, p. 84**
44. **Leaves and bark not aromatic 45**

45. **Bark exceedingly thick, leathery and tough; buds hidden under the base of the leaf stalks .... Leatherwood, p. 142**
45. **Bark and buds not as above 46**

46. **Twigs and leaves clammy with resinous dots when young. Huckleberry, p. 155**
46. **Twigs and leaves not as above 47**

47. **Buds inclosed in a single scale; flowers and fruit borne in catkins .... Willow, p. 68**
47. **Buds and flowers not as above 48**

48. **Leaves distinctly one-sided or oblique, at the base, wavy-margined; yellow flowers in late autumn, fruit ripening the following season .... Witch Hazel, p. 90**
48. **Leaves not distinctly one-sided at the base; flowers not yellow; fruit maturing the same season 49**

49. **Flowers in catkins 50**
49. **Flowers not as above 52**

50. Fruit an edible nut .... Hazelnut, p. 78
50. Fruit not as above 51

51. Fruit a small cone .... Alder, p. 76
51. Fruit not a cone .... Sweet Gale, p. 67

52. Fruit dry 60
52. Fruit fleshy 53

53. Fruit with a single stone 54
53. Fruit not as above 56

54. Stone two-seeded............... Alternate-leaved Dogwood, p. 147
54. Stone one-seeded 55

55. Drupe red; flowers before leaves.... Lady Laurel, Daphne, p. 143
55. Drupe brownish or black; flowers with leaves...... Cherry, p. 94

56. Fruit red or purple when mature 57
56. Fruit blue or black when mature 59

57. Fruit 10-seeded, edible .... Shadbush, p. 99
57. Fruit 5 to 6 seeded, not edible 58

58. Berries borne on a long stalk.............. Mountain Holly, p. 131
58. Berries without stalk (sessile) .... Winterberry, p. 131

59. Flowers bell-shaped; fruit sweet and edible...... Blueberry, p. 157
59. Flowers and fruit not as above........................... 60

60. Flowers white; fruit slightly astringent....... Chokeberry, p. 98
60. Flowers yellow-green; fruit very astringent, inedible.
Buckthorn, p. 135

61. Flowers small 62
61. Flowers large, 1 to 2 inches across.
Swamp Pink, Azalea, Rhodora, p. 172

62. Flowers urn-shaped .... Male Berry, p. 165
62. Flowers saucer-shaped 63

63. Flowers and fruit in narrow pyramidal clusters, 4 to 8 inches long .... Hardhack, Spiraea, p. 96
63. Flowers and fruit in rounded or flat clusters, 1 to 2 inches long .... New Jersey Tea, Redroot, p. 136

PINE FAMILY. CONIFERAE[1]

The plants of the pine family are nearly all evergreen trees, the pines, spruces, hemlocks, etc. They are characterized by their cone-like fruit and needle or scale-shaped leaves. Most of them are therefore described in an earlier bulletin, "Trees of Vermont."[2]

Three of these, however, are evergreen shrubs as they occur in Vermont, namely, the two junipers and the yew. The junipers and yew differ from the other Vermont conifers in having fleshy, berry-like fruits instead of dry, scaly cones. The young juniper berries are grayish-white, becoming bluish as they ripen, while those of the yew are green when young and turn to a beautifully bright coral-red in late summer.

THE JUNIPERS

There are three species of juniper in Vermont, the "red cedar," a well known and valuable tree, which has an upright trunk typically 20 to 40 feet high (see "Trees of Vermont") and the following two shrubs.

KEY FOR DISTINGUISHING THE TWO SHRUBBY JUNIPERS

Scale-like leaves spreading in whorls of three, berry-like fruits borne on the sides of the twigs (lateral)............Common juniper.

Scale-like leaves pressed close to stem, mostly opposite, berry-like fruits on the end of twig (terminal)........Shrubby red cedar.

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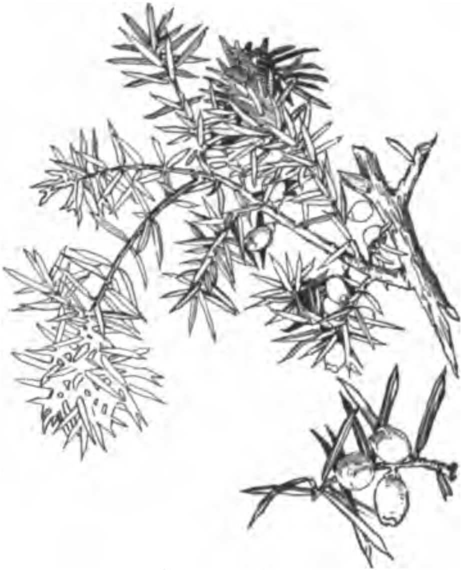
[1] The so-called "ground pines" are low evergreen plants common in Vermont woods and so closely resembling small pines and spruces that to avoid confusion they deserve mention here. There are several kinds but all are quite similar in general character. The branches, thickly covered with evergreen scale-like leaves, rise a few inches above the ground, either in small clusters or borne on an extensively creeping cord-like stem. The fruits on the commonest species are borne on slender cone-like clusters, one-eighth inch in diameter by one inch long, terminating the upper branches. The commoner species with trailing stems are frequently gathered in late autumn for making holiday wreaths, and hence are termed "Christmas greens." Although having so close a resemblance to the conifers they really belong to the fern family and are best called club moss or Lycopodium.

[2] "The Trees of Vermont," Vt. Sta. Bul. 73 (1899). This contains descriptions of all Vermont trees and, since it supplements the present bulletin at many points, it will frequently be referred to in this text. It may be secured and without charge so long as the now somewhat limited supply lasts. Address Experiment Station, Burlington, Vt.

COMMON JUNIPER. *Juniperus communis* L. var. *depressa* Pursh.

The common spreading juniper is frequent on dry hillsides and in rocky or sandy pastures of the Connecticut and Champlain valleys. Indeed it is often so abundant as to be a nuisance. It is a low outspread evergreen shrub, seldom over two or three feet high but often broadening into circular beds five to ten feet across. The horizontal branches lie half-buried in the soil and are frequently rooted so as to make the cluster difficult to eradicate. The leaves are green below and whitish above, arranged in a whorl of three, standing out nearly at right angles to the branch. They are one-third to one-half inch long, and have sharp rigid points which make contact with this shrub about as unpleasant as with a thistle. This probably aids in protecting the plant from disturbance by grazing animals and so contributes to its aggressiveness as a pasture weed. Little use is made of the juniper in America. In Europe, where people are more frugal, some value is attached to the wood, the bark affords material for rope-making and the berries are used for preparing gin and for medicinal drinks, esteemed in kidney troubles. This juniper has some value for ornamental planting where a low cover is desired on a warm dry slope. An upright form of it sometimes occurs in Massachusetts and may be expected especially in southern Vermont. European columnar forms, particularly the Swedish juniper, are used ornamentally.



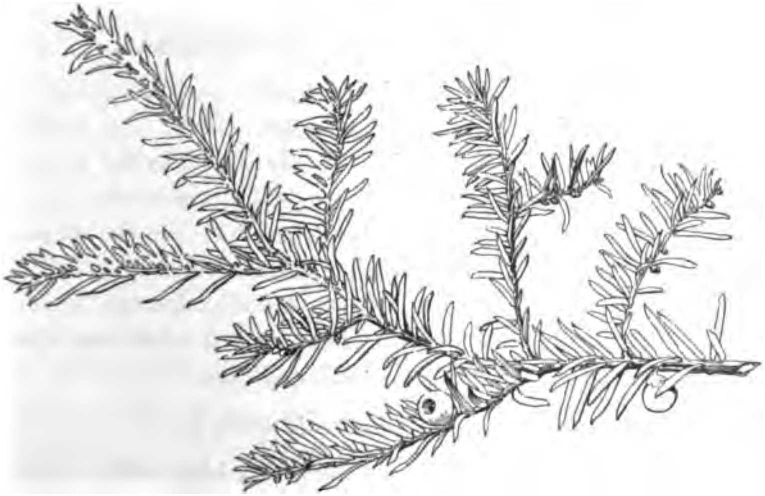
COMMON JUNIPER.
Fruiting branch, × ½.

SHRUBBY RED JUNIPER. *Juniperus horizontalis* Moench. (*J. Sabina* var. *procumbens* Pursh.)

This is a semi-prostrate or creeping shrub, seldom more than four feet high, usually with long trailing branches bearing numerous short branchlets. It has a close resemblance, except in its prostrate habit, to the common red juniper or "red cedar" tree. (See "Trees of Vermont." p. 46.) It has been found in only two places in the State, West Rutland and Manchester, and since it has no economic interest, it will be given only this brief notice. It is a matter of botanical concern, however, to learn further as to its distribution and any one finding it should report it to the botanists at the University of Vermont or elsewhere for verification and record.

GROUND HEMLOCK. AMERICAN YEW. *Taxus canadensis* Marsh.

The lover of rich colors must always rejoice when he comes upon a bed of the ground hemlock with its deep green foliage and bright red fruit. It is frequent throughout Vermont on cool moist banks under the shade of other evergreens. It is a low straggling shrub, the stems often trailing six or eight feet



AMERICAN YEW OR GROUND HEMLOCK.
Fruiting branch, × ½.

with upright branches only half that length. The foliage is much like the hemlock tree, hence its name. Like this, the leaves are narrow and flat and appear to be two-ranked, giving a light spray-like effect. They are, however, somewhat larger and darker colored than those of the hemlock tree, so as quickly to attract the attention. In autumn the red pulpy berries about one-fourth of an inch in diameter stud the branches like coral beads and at once serve to distinguish this from any other Vermont plant. Practically no use is made of the yew in Vermont. It is, however, worthy of planting for ornamental purposes, especially on cool moist banks under partial shade where few other plants can rival its rich combination of evergreen foliage and red fruit. The berries are sometimes reputed as poisonous. There is some evidence that the leaves, if browsed, may injure animals and that the seed also contains a similar poison, but the pulp of the berries is edible.

SWEET-GALE FAMILY. MYRICACEAE

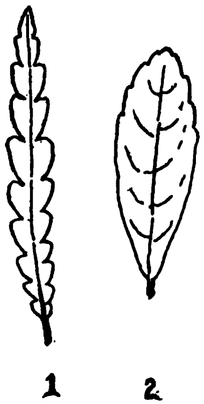
Vermont has two shrubs of this family, each attractive in its way, but neither generally common. They are readily separable by the shape of their leaves. As shown in the accompanying sketches, the sweet-fern has a leaf three to six inches long, deeply cut into many rounded lobes, whereas the sweet-gale leaf is small and only slightly toothed. Closely allied to these is the bayberry or wax-myrtle of Massachusetts and southward, which produces berries so richly coated with wax that they have been used for making candles and soap.

SWEET-FERN. *Myrica asplenifolia* L.

This is a shrub about one to three feet high with slender finely cut leaves, as described above, that give it a fern-like appearance. When crushed, these have a strong spicy aroma, hence its common name was well chosen although actually it is not a fern. The fragrance of the dry leaf when burned is familiar to many New England boys. The flowering catkins are abundant in early spring but are less conspicuous than the green burr-like fruit in midsummer. It is so common as to deserve its rating as a weed in the dry sandy pastures and on sterile hills at the lower altitudes of the Champlain and Connecticut valleys. In the earlier days of home remedies, sweet-fern had its place in the preparation of diet-drinks and herb medicines because of its tonic and astringent properties, being used internally for colic and externally as a liniment for bruises and rheumatic ailments.

SWEET-GALE. *Myrica Gale* L.

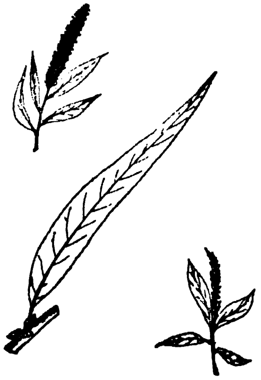
The sweet-gale is a little taller than the sweet-fern with simple narrow leaves one to two inches long, dark green above and pale below. It is frequent in Vermont in cool swamps and bordering ponds of the lower altitudes. It has no economic value in America although in the earlier days an infusion of the leaves or berries was sometimes used as a remedy for the itch and as a vermifuge. An infusion of the leaves is also sometimes used in Europe as an insecticide and it is said that the leaves if placed in drawers will keep out moths. The Canadian Indians used the young buds to dye their porcupine quills and all parts of the plant may be used in dyeing and tanning. In northern Europe the leaves are sometimes substituted for hops in brewing.



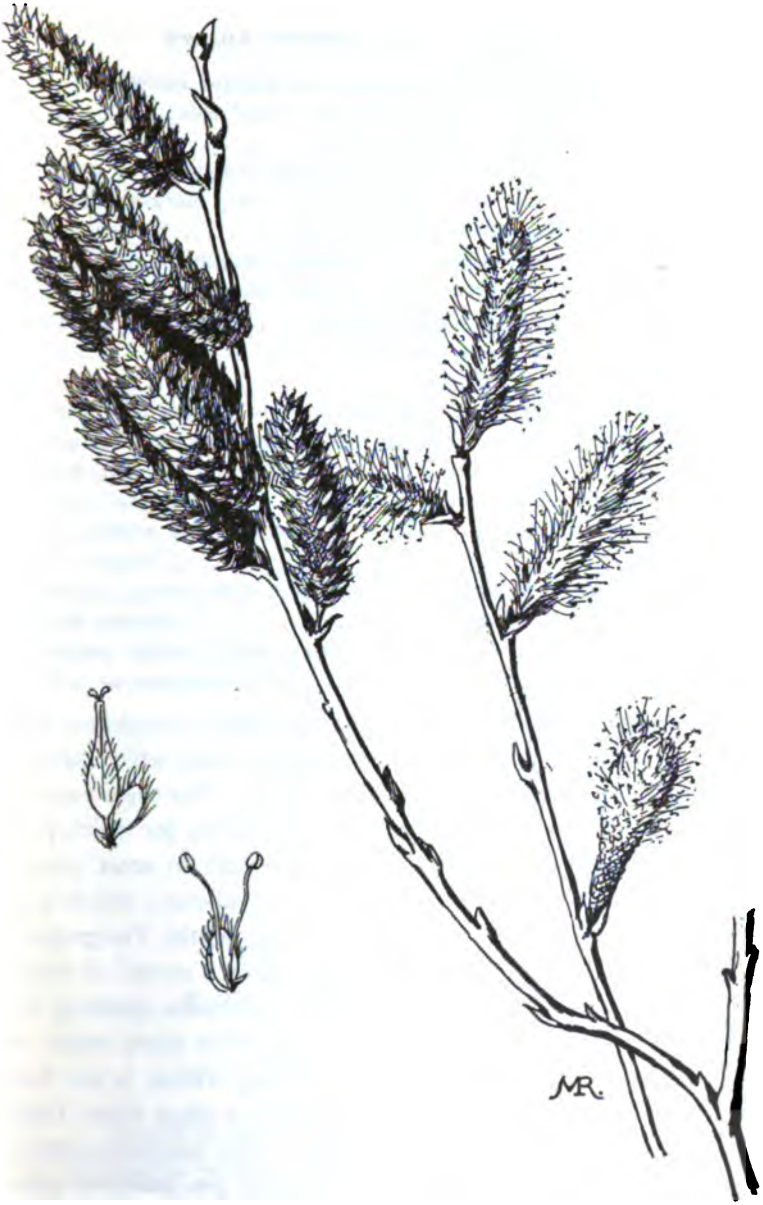
1. **SWEET FERN.**
2. **SWEET GALE,** × ⅝.

WILLOW FAMILY. SALICACEAE

This family includes the willows and poplars. The characters of each of these are so similar that any close observer soon distinguishes a willow or a poplar at sight. But it is quite another thing to know which willow or which poplar is before one. The species are all dioecious, that is the stamens and pistils are borne on different plants. As a result the poplars are dependent on wind and the willows on insects for pollination. Natural hybrids are more frequent than is commonly known, between the closely related species of willow. Hence any botanical student who will undertake their critical study will find interesting problems in nearly every swamp or wayside thicket. All of the poplars and four of the willows of Vermont have the habit and size of trees and are included in "Trees of Vermont" (pages 49-53). Of these the black willow is the only one which will confuse the person who is trying to recognize the shrubby species. This black variety is the commonest willow tree overhanging the stream banks and growing along lake shores and the younger sprouts often form shrubby thickets. This cut from the tree bulletin is therefore included here to aid in distinguishing it. There are in addition some fifteen species of willows in Vermont which are more properly termed shrubs. It is no simple matter even for the skilled botanist to distinguish with certainty these fifteen shrubby kinds. Fortunately for the beginner, only six of them are at all common. So if one groups the tree species by themselves and focuses his attention on the characters outlined on page 70 he may hope soon to recognize the common shrubby species.



BLACK WILLOW.
Mature leaf and flowering twigs, × ⅓.
(From Trees of Vt., p. 50).



PUSSY OR GLACOUS WILLOW.

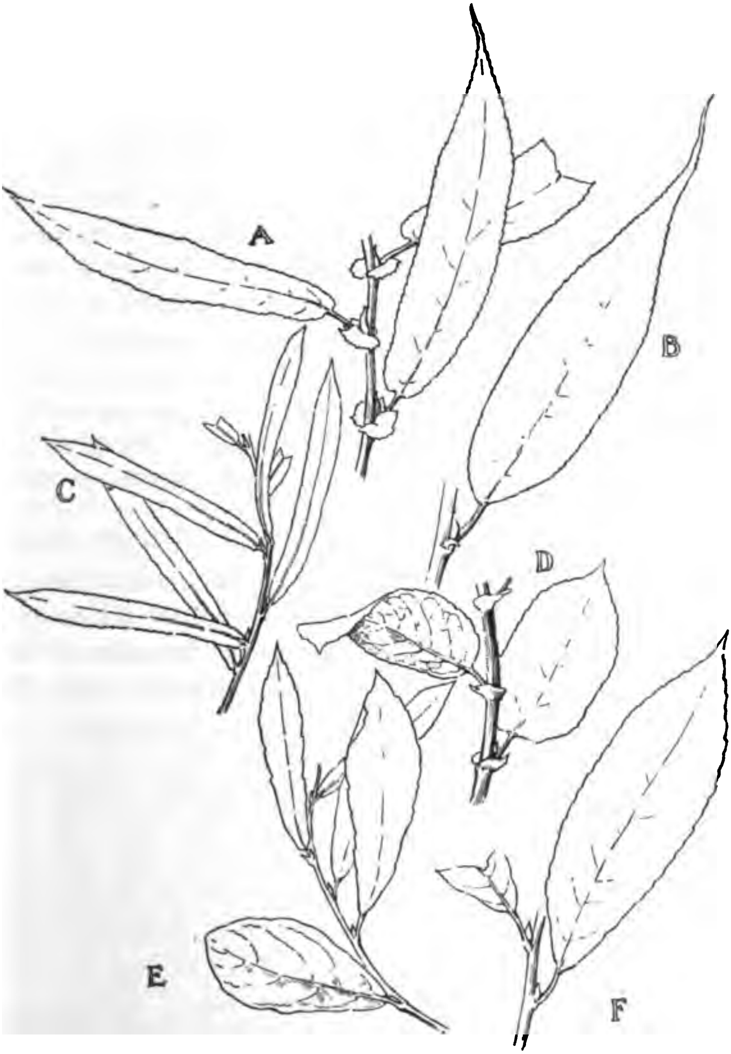
Staminate or pollen bearing branch at right, pistillate or seed-bearing at left, about natural size. Below at the left are single flowers of the two kinds, twice natural size.

KEY TO THE SIX COMMON SHRUBBY WILLOWS

(Based primarily on characters of mature leaves)

1. Mature leaves woolly or soft-hairy on under side..............2
1. Mature leaves smooth on under side 3
2. Leaves rather broad in proportion to length (length 2-3 × width) widest at about the middle, apex acute, margins flat or wavy. A large shrub of wide range ....Beaked willow.
2. Leaves narrower in proportion to length (length 3-4 × width) widest above middle, apex bluntish, margins rolled down. a small shrub of dry sand plains ....Prairie willow.
3. Leaves whitish (glaucous) on under side.....................4
3. Leaves green on under side 5
4. Leaves bluish-green above, long and narrow (length 6 × width or more), finely toothed, introduced for basketry, not common ....Purple willow.
4. Leaves bright green above, broader in proportion to length (length 3-4 × width) coarser toothed, a native shrub, common ....Pussy willow
5. Leaves shining as if polished, smooth even when young, stipules small and inconspicuous ....Shining willow.
5. Leaves not shining, usually silky-hairy when young, stipules relatively large ....Heart-leaved willow.

The willows are remarkable for the length, toughness and vitality of their roots and for the readiness with which broken branches strike root and throw up new shoots. For these reasons they are nature's best covering to hold river banks, for which purpose the introduced tree species are preferable in most places. The bark possesses a bitter tonic principle (salicine) which may replace quinine in medicine and is also rich in tannin. The greatest economic usage of the willows is, however, as a source of osiers for making basketry and furniture. For landscape planting the willows have value but the shrubs are not of so much worth as the viburnums and dogwoods. The shining willow is the best for foliage effect and the beaked willow has a place where large mass effects are desired on drier ground. The European species which have been improved by long selection are, however, generallv preferable to the natives for ornamental and other uses.



LEAVES OF THE SIX COMMON SHRUBBY WILLOWS, × ½.

A, Heart-leaved willow; **D, Beaked willow;**
B, Shining willow; **E, Prairie willow;**
C, Purple osier willow; **F, Pussy or glaucous willow.**

PUSSY OR GLAUCOUS WILLOW. *Salix discolor* Muhl.

This is the favorite pussy willow, conspicuous everywhere in early spring along streams and in moist wayside thickets. All of the willows have their flowers in similar catkins, but no other of the early ones is so large and bright as this. The staminate, or pollen-bearing catkins are bright yellow, while on other plants at the same time occur the duller ones which are pistillate and in May ripen the crop of downy seeds. This glaucous willow is one of the largest of the shrubby willows, often ten to twenty feet high, and the branches and foliage are relatively coarse. The leaves are often three to five inches long and are characterized, as explained in the key, by being bright green above and glaucous or whitish beneath, whence its name. The buds also are large and dark colored. Sometimes it is tree-like in habit.

BEAKED WILLOW. *Salix rostrata* Rich. (*S. Bebbiana* Sarg.)

This is closely related to the pussy willow and occurs frequently with it but shows a preference for drier soil. It is from six to eighteen feet high, does not spread from the root and often has the habit of a small tree with a distinct trunk. The catkins appear as distinguishing features in early spring with the leaves rather than ahead of them, as with pussy willow. The seed capsules are borne on long thread-like pedicels and taper to an especially long slender beak, which gives the distinctive name. In summer after the flowers and fruit are gone one must rely on the leaf characters described in the key, the mature leaves being dull green above, stoutly veined and soft-hairy beneath. The leaf margins vary from toothed to nearly entire. The young twigs are also minutely hairy. Owing to its wide soil adaptation, this species may well be used in planting where a willow is desired for mass effect.

PRAIRIE WILLOW. *Salix humilis* Marsh.

This is the common willow of dry, sandy barrens, rarely found elsewhere. It is two to eight feet high with leaves somewhat smaller than the last, dark green and smooth above, persistently gray-woolly below with the margins commonly more or less rolled downward or reflexed.

SHINING WILLOW. *Salix lucida* Muhl.

The shining willow is a tall shrub or low bushy tree of six to fifteen feet, common on moist banks and roadside thickets throughout the state. It is easily recognized by its glossy or shining leaves which may flash the light as if wax-polished. These are large, (three to five by one to one and one-half inches) taper pointed, darker above but also green and shining below. The staminate catkins are large and showy but less familiar than those of the pussy willow, partly because they are later, appearing with the leaves in early May. It deserves wide use for ornamental planting, being the most valuable of the native willows for this purpose, both on account of its beautiful lustrous foliage and its showy catkins. For such purpose the staminate plants should be selected. Since the sex cannot be determined in young plants, for such use, old roots should be moved or else cuttings taken from the desired plants. Although preferring moisture it will grow in dry soil.

HEART-LEAVED WILLOW. *Salix cordata* Muhl.

The heart-leaved willow is a tall, stout, branched shrub of five to twelve feet, with a number of varieties and hybrids. This is common with the pussy willow in low wet soils throughout Vermont. The flower catkins precede the leaves and are comparatively small and slender. The twigs are slightly downy or smooth. The leaves serve best to distinguish it, being long and narrow, lance-shaped, with base usually somewhat rounded or heart-shaped and margins varying from sharply toothed to nearly entire. They are green on both sides or slightly paler beneath, the young ones often silky or downy but becoming smooth with age. The stipules are usually large and conspicuous, especially on the vigorous young shoots and help in its recognition.

PURPLE OSIER WILLOW. *Salix purpurea* L.

This is one of the favorite basket willows of the old world. It is not a native of America but was widely introduced in the eastern colonies by the early settlers. In this way it was established throughout Vermont and it has since persisted and spread in moist soil along water-courses. It is also sometimes planted for ornament. It may be recognized by its long slender purplish-green branches and its narrow smooth dark green leaves which have a blue cast above as seen in mass and are somewhat glaucous or whitish beneath. Upon drying the leaves and young twigs turn purplish black which probably suggested the name of the species. Willows of fine quality for basket making can be grown in Vermont and doubtless there will sometime be a revival of attention to this industry. Its development is primarily dependent upon local labor conditions since basket making as a winter occupation must, as a rule be combined with some summer industry. At Syracuse, N. Y., it is so associated with the salt works.

THE LESS COMMON VERMONT WILLOWS

In addition to these six common shrubby willows there are nine or ten others, all rare. These will merely be listed with brief statement as to occurrence. For descriptions, reference may be made to botanical texts. It will be noted that three of these are mountain species, that two grow in cold bogs, and that four are found on shore regions.

BALSAM WILLOW. *S. balsamifera* Barratt. A northern species known only at Mt. Mansfield, Elmore Mountain and Long Pond in Westmore.

TEA-LEAVED WILLOW. *S. phylicifolia* L. An alpine species, moist ravines, summit Mt. Mansfield.

BEAR-BERRY WILLOW. *S. Uva-ursi* Pursh. Prostrate on bleakest portions of summit, Mt. Mansfield.

BOG WILLOW. *S. pedicillaris* Pursh. Occasional in peat bogs of the Champlain valley.

HOARY WILLOW. *S. candida* Flügge. Occasional in cold bogs.

SAND-BAR WILLOW. *S. longifolia* Muhl. (*S. fluviatalis* Nutt.) Occasional on sand shores of Lake Champlain and Connecticut River.

SLENDER WILLOW. *S. petiolaris* Smith. Frequent in Lake Champlain swamps.

SILKY WILLOW. *S. sericea* Marsh. Frequent in swamps and along streams.

NORTHERN HOARY WILLOW. *Salix pellita* Anders. Only one station is known at Bloomfield.

OAK FAMILY. CUPULIFERAE

This family includes among trees, the oak, birch and chestnut, all of which are described in "Trees of Vermont." There are also two shrubby species of oak found in southern Vermont, the bear oak, (*Quercus ilicifolia* Wang.) and the scrub chestnut oak (*Q. prinoides* Willd.), reference to both of which will be found in the bulletin cited. Two other groups of shrubs are also of this family, the alders and the hazel-nuts. Their flowers appear in very early spring in separate clusters on the same plant. The staminate or pollen-bearing hang as long, pendent catkins; the pistillate or seed-producing are small and upright, looking more like buds than flowers.

THE ALDERS

There are three well-marked species of alder in Vermont with possibly a fourth. Only two of them are common but all three are included in the following key. Alder bark is rich in tannin and has also medicinal properties. It is not, however, much used in America.

KEY TO VERMONT ALDERS

1. Flowers developed in earliest spring before the leaves, leaves not sticky (glutinous). The common alders of the lower altitudes 2

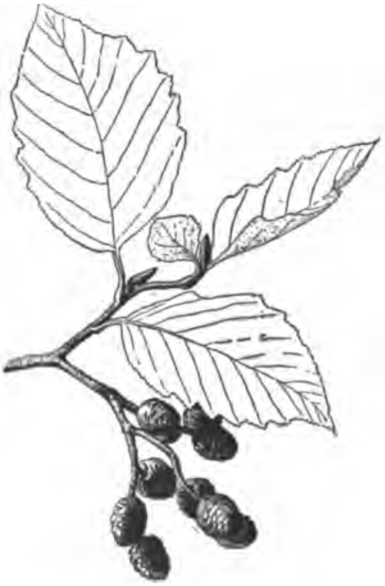
1. Flowers developed in spring with the leaves, young leaves sticky (glutinous). Rare species of the mountains and cool banks. Green alders.

2. Leaves whitish and mostly hairy or downy beneath. Usually pointed at the tip and rounded or cordate at the base. Hoary alder.

2. Leaves green both sides, usually smooth underneath rounded at the tip and more or less wedge shaped at base..Smooth alder.

HOARY OR SPECKLED ALDER. *Alnus incana* (L.) Moench.

This is the common alder of Vermont which borders every stream and is the plague of the trout fisher. It often forms dense shrubby thickets, while individual specimens may show the habit of small trees twenty feet high. The leaf and cone-like fruit are well shown in the figure. The leaves often vary, and a fungus may cause some of the scales of the cones to develop numerous curled, tongue-like outgrowths, often an inch long. Very little use is made of the alder in Vermont, although where large enough it makes excellent fuel. Formerly the charcoal burners used it, making an unusually good product from it. In Japan where it attains a height of sixty feet or more it furnishes valuable wood. While at first thought this would be rated a plant of little or no value, it doubtless proves more serviceable

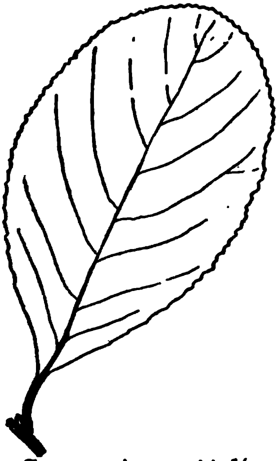


HOARY ALDER.
Leaf and fruit, × ½.

than is any other plant or shrub as a means of preventing the banks of streams from washing away. If nature did not plant it, the land owners would probably have to provide some substitute as a soil binder.

SMOOTH ALDER. *Alnus rugosa* (Du Roi) Spreng. (*A. serrulata* Willd.)

The smooth alder is the common species from Massachusetts southward and naturally is more common in southern Vermont than northward. In general character and habit it is almost like the preceding. In well-marked forms it is easy to distinguish the two by the leaves. It should be noted, however, that an intermediate form often occurring along the shores of Lake Champlain puzzles the student. The leaf of this form has the shape of the hoary and the color of the smooth alder. It is listed as a hybrid in the "Flora of Vermont"; but whether or not this is the true explanation must be determined by further study.



SMOOTH ALDER, × ½.

THE GREEN ALDERS

There are two rarer northern species easily distinguishable from the preceding by their smaller rounder leaves which are distinctly glutinous especially on the under side. It is also an interesting fact that the fruit of these green alders seems free from the gall fungus. The typical green alder (*A. crispa* (Ait.) Pursh., *A. viridis* DC.) is found only on the higher mountain summits. It is a small shrub of from two to six feet. The larger form of lower altitudes which may rival the common alder in size has recently been described as a distinct species (*A. mollis* Fernald). It is distinguished from the mountain species by more pubescent shoots and lower leaf surfaces.

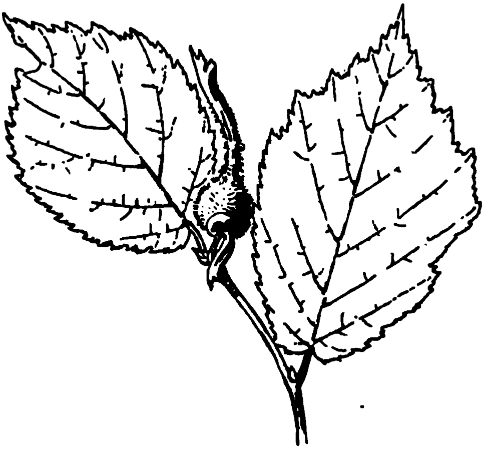
HAZELNUTS

There are two species of hazelnuts in Vermont. Only one, the beaked hazel, is common, and there is scarcely enough of this except in some of the higher mountain pastures to tempt boys to harvest the nuts. Further west and south the larger American hazelnut is more common and is gathered in quantity by country children. In Europe a related species, the European hazel (*Corylus avellana*) has been improved and brought into culture, furnishing the familiar filbert-nut of commerce. Sometimes the hazelnut is confused with the witch-hazel described later in this pamphlet. There is no occasion for this, however, other than the name. The two hazelnuts are readily distinguishable by the fruits as follows:

Husks (involucral bracts) united and prolonged into a long tubular beak, about twice the length of the nut......Beaked hazelnut.
Husks nearly distinct and not prolonged into a beak. American hazelnut.

BEAKED HAZELNUT. *Corylus rostrata* Ait.

This is the common hazelnut of Vermont, frequent in dry wayside thickets throughout the state. It is a small shrub,

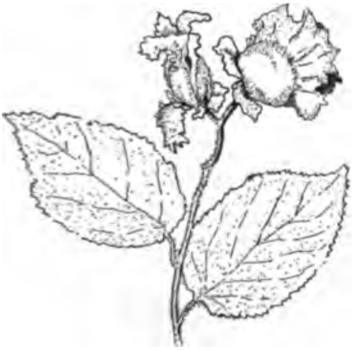


BEAKED HAZELNUT.
Leaf and fruit, × ½.

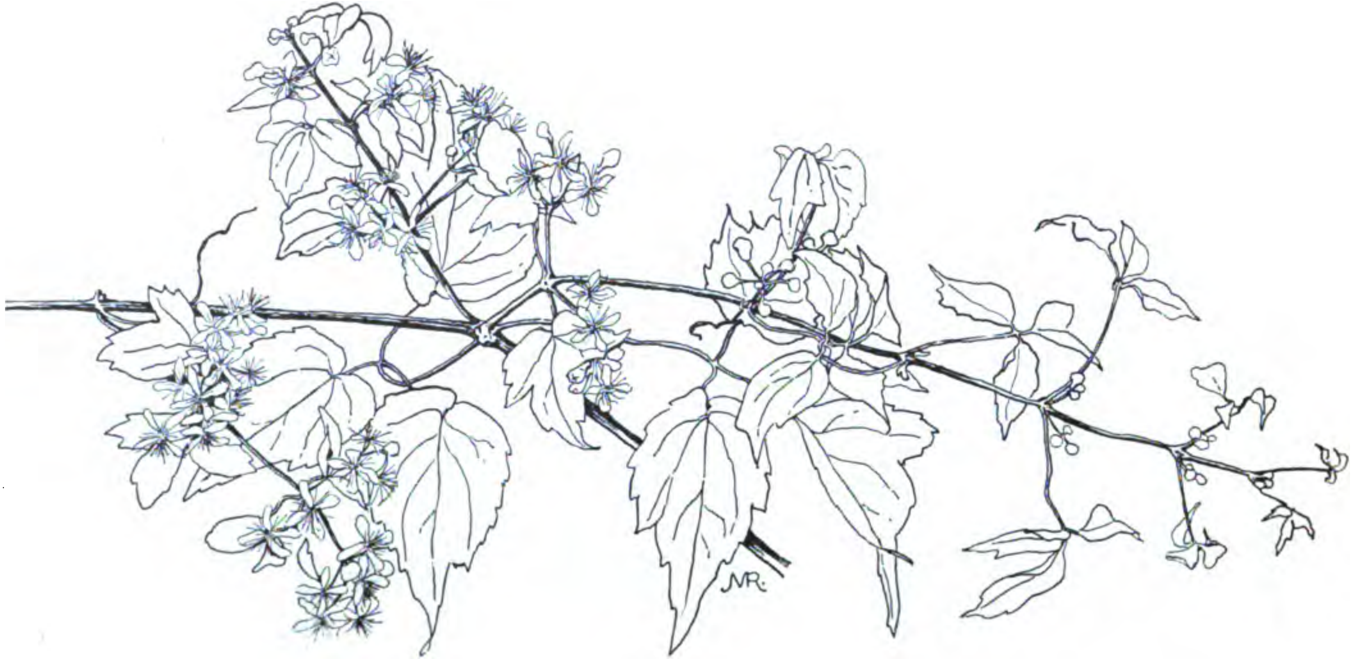
usually of three to five feet, with stems small and clustered owing to a tendency to throw up suckers from the base. The shape of leaf and fruit are well shown in the accompanying cut. The leaf is usually two to three inches long, and rather harsh to the touch. The flowers appear before the leaves in earliest spring. The staminate or pollen-bearing are in graceful drooping catkins; the pistillate ones, from which the nuts are to develop, are smaller, budlike and scarcely noticeable except for the bright red stigmas protruding from the scales. The bracts rapidly enlarge in early summer and show the beaked character, but the nuts do not mature till autumn.

AMERICAN HAZELNUT. *Corylus americana* Walt.

This is naturally a more southern plant than the preceding, thriving at its best in the warmer, longer summers found southward and westward. The shrub is taller and the nut somewhat larger than that of the other species. The nut varies much in quality and size, the best being nearly as large as the ordinary market filberts and of quite as agreeable flavor. Without doubt the best of these will some day be brought into culture and probably improved as the European species has been.



AMERICAN HAZELNUT, × ½.



Virgin's Bower.
Flowering branch, × ½.

CROWFOOT FAMILY. RANUNCULACEAE

Herbs like the common buttercups and anemones are more typical of this family than are the woody members. Two species of clematis, the most attractive of Vermont's flowering vines, are the only representatives of the latter class. Both have slender, weak stems, somewhat woody below, and climb by the strong leaf-stalks which clasp any available support. The foliage and flowers are graceful and the fruit scarcely less so, making these the most dainty of our native vines, whether in their natural habitats or when brought into culture. The two species may be distinguished as follows:

Flowers small (one-half to one inch), white, in leafy clusters.
Virgin's bower.
Flowers large (two to four inches), purple and solitary.
Purple clematis.

VIRGIN'S BOWER. *Clematis virginiana* L.

This is a familiar sight fringing streams and moist thickets, soon converting the ugliest spot into a place of beauty. Its compound leaves have each three leaflets with clasping petioles. The plants are dioecious, that is, some have only pollen-bearing flowers and others only seed-producing ones. The fruits are provided with long feathery tails and as they ripen in autumn are almost as showy as the flowers. If one is selecting vines for ornamental planting, he should aim to secure a good proportion of these fruitful plants.

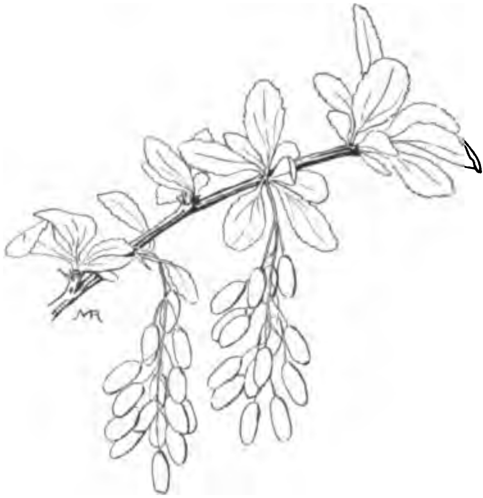
PURPLE CLEMATIS. *Clematis verticillaris* DC.

This is a rather rare plant on rocky hills. It is a weaker climber and less luxuriant than is the other species, hence is somewhat less desirable as a screen or fence-cover. Its strikingly beautiful flowers however compensate for this weaker and less luxuriant habit of growth and make it one of the peculiarly attractive native ornamental vines. Its fruits have feathery appendages like the virgin's bower, giving it a charm in autumn as well as in spring.

BARBERRY FAMILY. BERBERIDACEAE

COMMON BARBERRY. *Berberis vulgaris* L.

There are no native plants of this family but the common barberry, originally introduced from Europe, has now become so frequent an escape by roadsides and in waste places as often to appear as if native. It is a shrub of six to eight feet with thorny branches and bristly leaves. The younger branches have a gracefully arching habit and produce in late spring an abundance of small yellow flowers in drooping clusters followed by masses of fruit which redden beautifully in autumn and persist through the winter. It will grow well on even the thinnest of soils. It also bears pruning at will. These characters combine to make it one of the most valuable of shrubs for ornamental planting, especially for hedges or close groups to exclude trespassers. The berries though tart are edible and throughout New England are employed in the concoction of preserves, particularly in combination with fruits of milder quality, like the apple. They are sometimes put in cucumber pickles. No other use is made of the plant here, we believe, but the barberry has been used from ancient times for medicine and dye and for tanning leather. The tannin occurs in the bark. A yellow coloring matter is found in the bark, more especially in that of the root, the extract from which can be used for dyeing cloth or leather.

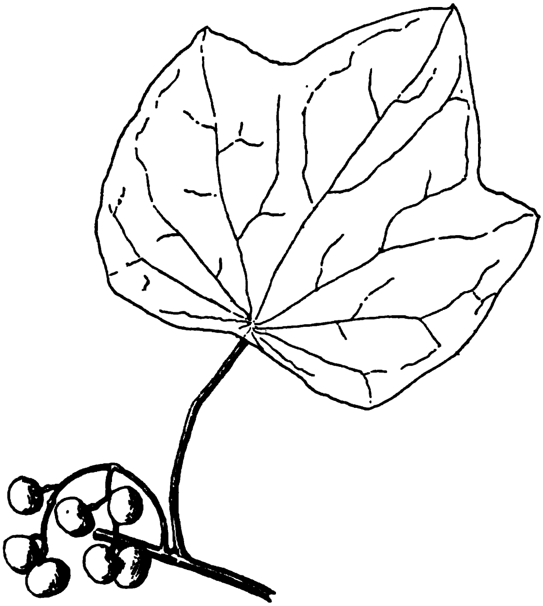


BARBERRY.
Fruiting branch, × ½.

MOONSEED FAMILY. MENISPERMACEAE

MOONSEED. *Menispermum canadense* L.

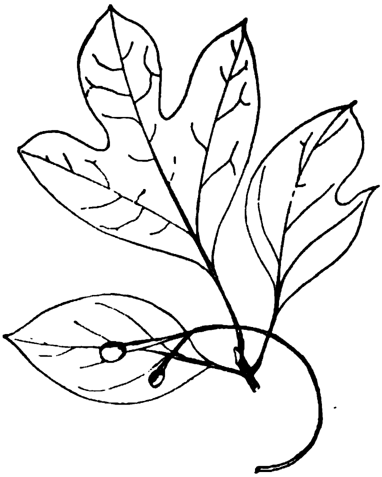
The moonseed is the only native representative of its family. It is a slender, perennial, twining vine, somewhat woody below but herbaceous above, which occurs occasionally climbing over shrubs on the banks of streams and in low thickets. It is easily recognized by its leaf which is rather large, four to six inches across, of unusual shape and veining as shown in the drawing, the petiole is attached just within the margin and the under side is paler and strongly veined. The flowers and fruits are rather inconspicuous. This is sometimes used for ornamental planting and the roots are reputed to possess medicinal virtues.



MOONSEED, × ½.

LAUREL FAMILY. LAURACEAE

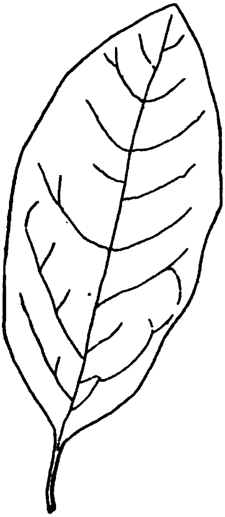
This family takes its name from the laurel or bay-tree of Europe, the leaves of which were the emblem of victory. The name laurel is commonly applied in this country to certain shrubs of the heath family, the mountain laurel and sheep laurel to be described later. The only members we have of the laurel family properly speaking, however, are the sassafras and spice-bush. The former is a small tree common from Massachusetts southward. It is at its northern limit in southern Vermont where it occurs but sparingly. It does not often reach the stature of a tree in this state but nevertheless it was described in "Trees of Vermont." We will simply reproduce the plate here showing the peculiar leaf outline and refer to that bulletin for further description. The medicinal qualities of sassafras have long been celebrated.



SASSAFRAS
Leaves and young fruit, × ⅛

SPICE-BUSH. FEVER-BUSH. *Benzoin aestivale* (L.) Nees. (*Lindera benzoin* Blume.)

This is a rare plant in Vermont found in the shade of moist woods and along streams. It is a shrub of four to six feet with slender twigs and graceful habit. The flowers are small and yellow appearing in nearly sessile clusters in early spring ahead



SPICE BUSH, × ½.

of the leaves. The leaves are alternate, two to five inches long, with entire margins, paler beneath, smooth or rarely downy. The botanical name was suggested by the strong aromatic odor resembling gum-benzoin, which resides in all parts of the plant. This shrub is worthy of ornamental planting, doing best in shaded situations. An infusion of the bark is sometimes used as a tonic and stimulant, especially in intermittent fevers and the leaves served the southerners as a substitute for tea during the civil war. In revolutionary times the powdered fruits were used in place of allspice.

SAXIFRAGE FAMILY. SAXIFRAGACEAE

This family includes only the one genus of woody plants, the others being the herbaceous saxifrages and mitreworts.

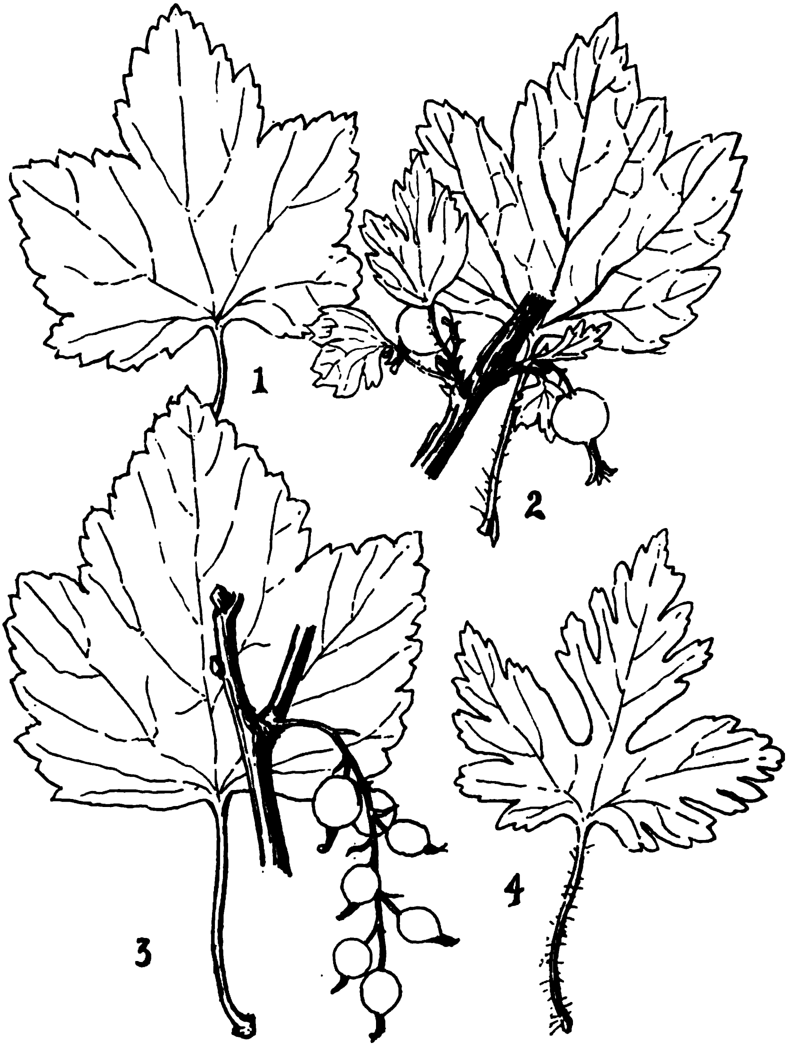
CURRANTS AND GOOSEBERRIES

Vermont has three native species each of the currant and of the gooseberry. They all have leaves so similar as to suggest the family relationship: they are simple, palmately veined and lobed and usually borne in small clusters. The fruit also is characteristic. Where the species is unknown the following key will aid in its recognition:

1. Stems usually bearing thorns at the base of leaf stalks or leaf clusters and often with scattered bristly prickles; berries prickly or smooth. (Gooseberries) 2

1. Stems without thorns or prickles. (Currants)................4

2. Flowers several (a raceme) on a nodding stem, twigs and fruit bristly ....Swamp gooseberry.



1, Mountain Currant;
2, Smooth Gooseberry;
3, Swamp Red Currant;
4, Swamp Gooseberry.

Natural size.

2. **Flowers in clusters of one to three, stems without thorns or bristles except at base of leaves 3**
3. **Flower stems short (about one-half inch), fruit smooth. Smooth gooseberry.**
3. **Flower stem one inch or more, fruit usually with prickles. Prickly gooseberry.**
4. **Flower clusters erect, berries bristly..........Mountain currant.**
4. **Flower cluster drooping, berries smooth 5**
5. **Flowers large, bell-shaped, whitish; berries black when ripe. Black currant.**
5. **Flowers small, flat, greenish; berries red when ripe..Red currant.**

THE GOOSEBERRIES

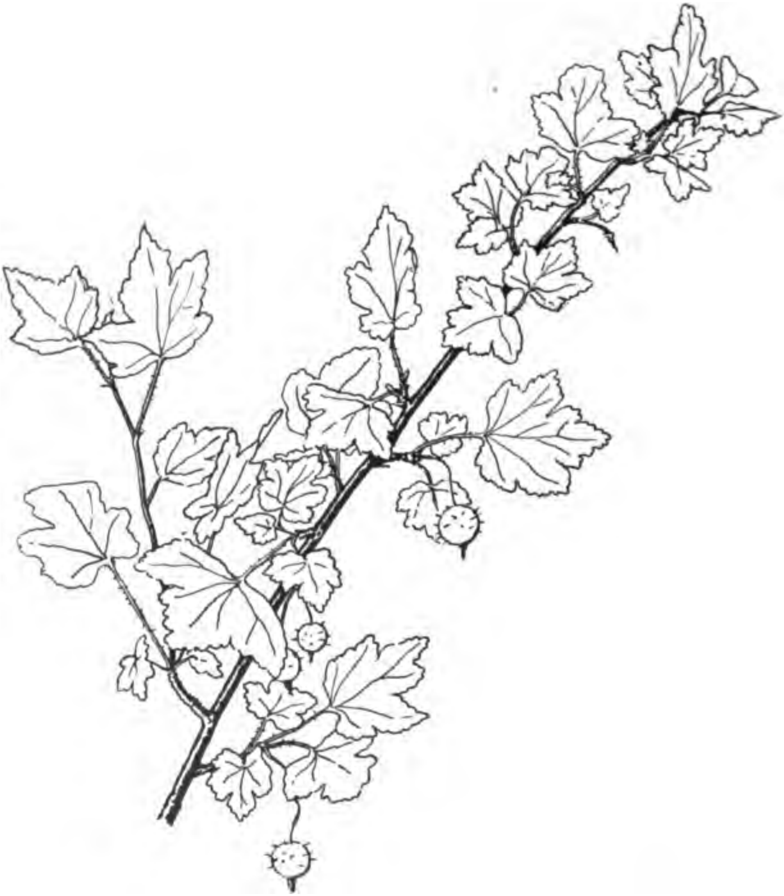
A considerable use was made by the early settlers of the fruit of the wild gooseberries. That of the swamp gooseberry is small and unpleasant, but both of the others are good. In England the wild gooseberry is inferior to these, yet from it by culture and improvement they have produced cultivated fruits which are very productive with berries as large as small plums. These European gooseberries are liable to mildew and are not fully hardy in Vermont, hence we must depend on American types. The gooseberries commonly seen in Vermont gardens originated from the American smooth gooseberry. Both this and the prickly berry offer promising opportunity for further breeding, selection and improvement.

SMOOTH GOOSEBERRY. *Ribes oxyacanthoides* L.

This is frequent in cold wet woods and swamps throughout Vermont. It is a spreading shrub a few feet in height, with slender branches and thorns at base of leaf clusters short and sometimes lacking. The shape of the leaves is shown in the drawing. They are thin and finely pubescent below, three to five lobed and toothed. The flowers are on short stalks, bell-shaped. The fruit is a smooth globular berry, one-third to one-half inch in diameter, either green or reddish when ripe and delicious in preserves or jam. This is the parent of the cultivated American gooseberries like Houghton and Downing.

PRICKLY GOOSEBERRY. *Ribes Cynosbati* L.

This is the common gooseberry of rocky woods. It generally has slender pointed thorns at the base of the leaf cluster and often the branches have scattered prickles in addition. The leaves are usually roundish heart-shaped at the base and slightly downy beneath and on the stem. The berries are one-third to one-half inch in diameter, armed with long prickles or rarely



PRICKLY GOOSEBERRY.
Fruiting branch, × ½.

smooth, ripening to a dull purple. It is sweet and edible, not infrequently cultivated and well worthy of further trial and improvement.

SWAMP GOOSEBERRY. *Ribes lacustre* (Pers.) Poir.

This is frequent in cold swamps and wet mountain woods. It is an upright shrub of three to four feet, the young stems clothed with bristles. The leaves are heart-shaped at the base and deeply three to five lobed, this deep lobing distinguishing it from any of the other species. The purplish flowers are open bell-shaped. The berries are reddish, covered with weak bristles, very small (one-sixth inch) and of unpleasant flavor. The only use ever made of this is for ornamental planting in wet soils.

THE CURRANTS.

RED CURRANT. *Ribes triste* Pall. var *albinervium* (Mx.) Fern.
(*R. rubrum* L. var. *subglandulosum* Maxim.)

The cultivated red and white garden currants are descended from the European red currant known as *Ribes vulgare.* Our native American variety differs but slightly therefrom except in habit. It is occasionally found in cold damp woods or bogs. Its general characters so closely resemble those of the familiar garden currants that description here is needless. The berries are smaller than the garden varieties, bright red and edible.

The natural growth of this wild currant in cold, wet woods explains why the cultivated currants do so well in cool moist soil, with abundant fertility, and have preference for northern exposures or even partial shade.

BLACK CURRANT. *Ribes floridum* L'Her.

The black currant is a more or less erect shrub found scattered in woodlands. The conspicuous drooping clusters of flowers followed by the rather large black berries render it easy of recognition. If one is in doubt however, a distinguishing mark may be found in the tiny, yellowish resinous dots sprinkled over the leaf surface, barely seen with the naked eye but clearly evident with a magnifying glass. This currant is sometimes transferred to garden culture and is a fruit of some present value and of much promise when attention may be given to its improvement. It is closely related to the European black currant which is prized by foreigners as a garden fruit.

BLACK CURRANT, × ½.

MOUNTAIN CURRANT. *Ribes prostratum* L'Her.

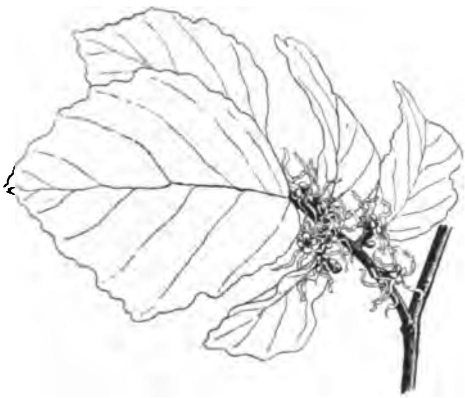
This also goes under the names of skunk currant or fetid currant, which well characterize it since the bruised fruit and, to a less degree, the foliage emit an unpleasant odor, much like the skunk cabbage. The name mountain currant is also well applied since it is one of the common and characteristic shrubs of the higher mountain woods. The Latin name was chosen because of the reclining habit of the main stems which lie along the ground and frequently root, sending up shorter erect branches. The fruit is small, bristly and of such disagreeable flavor as to preclude any use being made of it.

WITCH-HAZEL FAMILY. HAMAMELIDAE

This family includes the liquidambar or sweet-gum tree of the South but in Vermont is represented by the witch-hazel only.

WITCH-HAZEL. *Hamamelis virginiana* L.

It is a rather curious fact, and somewhat of a reproach to current methods of education, that there are probably a score of people who are acquainted with witch-hazel extract for one who is familiar with the witch-hazel plant, even in those sections of Vermont where it is common. It is a tall bushy shrub of five to fifteen feet or sometimes a small tree of twenty feet or more, with long forking brown branches. The leaves are rather large and of easily recognizable shape with wavy margin and oblique base as shown in the figure. The flower and fruit both have unusual and interesting characters. Witch-hazel is unique among our shrubs in that it blossoms in very late autumn. What is more cheering after the early frosts than to come upon this shrub already leafless but with branches fringed with delicate yellow blossoms prophetic of the return of spring? The flowers are thus fertilized in the autumn, but the fruit does not enlarge until the next season, when the downy, nut-like, oval capsules become about one-half inch or more long and in the early autumn split elastically at the end in such a way as to shoot to some distance the rather large glossy-black seeds. On a sunny autumn day these may be heard snapping like toy pistols in the wayside thickets. A few branches with unopened fruit placed in the school room will illustrate in a convincing manner the effectiveness of nature's provision for seed dissemination. Witch-hazel has value as a shrub for ornamental planting because of its compact habit, clean bright foliage and autumnal flowers. Witch-hazel extract is familiar as a mildly soothing lotion. It is made by pounding or chopping the bark of the young twigs and roots and extracting, either with water, as the American Indians did, or with alcohol as prescribed by



WITCH-HAZEL.
Flowering in autumn, × ½.

the modern pharmacopaea. The forked branches of the witch-hazel were formerly much used as "divining rods" in searching for hidden springs of water or deposits of ore, a use reflected in its common name.

ROSE FAMILY. ROSACEAE[1]

This is the most numerous family of native shrubs as well as the most useful. More than forty species and varieties are listed in the following pages and it is to be remembered in justice to the family's importance that it includes in addition a dozen or more native trees and a much larger number of herbaceous plants. The rose family has given us nearly all of the finest fruits of the temperate zone as well as the favorites among the woody ornamental plants. One needs only a partial list to realize the value to man of this one family. It includes among the fruits, the apple, pear, quince, peach, plum, cherry, almond, raspberry, blackberry, strawberry. Among the ornamentals are the rose, hawthorn, spiraea, nine-bark, flowering quinces and almonds; and to this list might be added an indefinitely long list of lesser importance. The value of these plants economically is much enhanced by their variability. In the rose family we frequently find nature in the process of species making, that is to say the plants are in a variable or plastic state, not yet stable and finished products. This gives the horticulturist his opportunity to select and shape at pleasure, as we see in the countless varieties of the rosaceous flowers and fruits listed above, many of them (e. g. all the apples) derived from a single species. But for the botanist of classical type who is happy in proportion to the exactness of his system of classification, this family offers problems at every turn. The common roses and blackberries may puzzle even an expert and the relationships among the thorn apples in a single rocky pasture may present questions impossible of satisfactory answer at present. While every beginner in botany should early make the acquaintance of the rose family, it need not discourage him, or even the most advanced student, if forms are found which depart from the accepted descriptions of species.

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[1] **Mr. W. W. Eggleston carefully edited this account of the rose family and prepared the descriptions and keys in the more critical genera, including the blackberry-raspberry group (*Rubus*) the rose, the thornapple and the shad-bush.**

With this warning, an attempt is here made to reduce the characterization of the commoner shrubby species to such simple terms as well suffice for their recognition:

KEY TO GENERA OF ROSACEOUS SHRUBS.

1.	**Pistil single, maturing into a single cherry-like fruit**	**Cherries.**
1.	**Pistils several, fruit not cherry-like**	**2**
2.	**Leaves simple**	**3**
2.	**Leaves compound**	**4**
3.	**Fruit inconspicuous and dry**	**Hardhacks.**
3.	**Fruit conspicuous, fleshy**	**5**
4.	**Fruit inconspicuous and dry**	**Cinquefoil.**
4.	**Fruit conspicuous, fleshy (blackberry and raspberry)**	**Rubus.**
4.	**Fruit conspicuous, a rose hip**	**Roses.**
5.	**Seeds with hard, bony covering**	**Thorn apples.**
5.	**Seeds with thin, membraneceous covering**	**6**
6.	**Fruit black, flesh puckery and dry**	**Chokeberries.**
6.	**Fruit red, sweet and juicy**	**Serviceberries.**

CHERRIES.

There are seven species of cherries and one plum spontaneous in Vermont, aside from the numerous garden varieties. The plum and five of the cherries were included in bulletin 73, "Trees of Vermont." One kind, the choke-cherry, discussed in the former bulletin, is better described as a shrub but since it was there described and is so familiar a plant it will simply be figured here. The wild red cherry also has often a habit as well termed shrubby as tree-like but that too was described in the tree bulletin and so will here be omitted. There are, however

CHOKE CHERRY. Leaves, flowers and fruit, × ¼.

WILD RED CHERRY. Leaves, flowers and fruit, × ⅛.

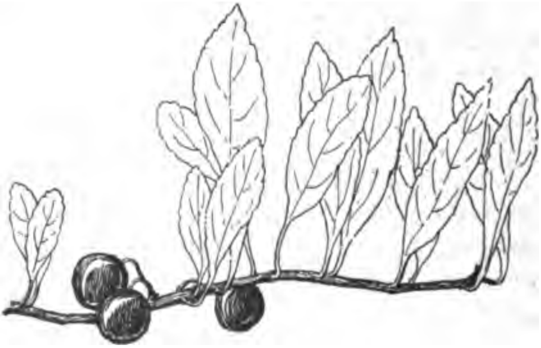
(From Trees of Vermont).

the two dwarf sand cherries, characterized by low shrubby habit and other characters as follows:

Older stems trailing ....Sand cherry.
Stems upright ....Appalachian cherry.

SAND CHERRY. *Prunus pumila* L.

The sand cherry occurs occasionally in Vermont, usually on rocky or sandy banks of streams. The main stems are semi-prostrate, the younger branches more or less erect, sometimes a foot or two in height. The leaves are quite long and narrow,



SAND CHERRY, × ⅜.

tapering to base and apex, sharp pointed and sharply toothed toward the apex. The fruit is a small, dark red cherry, nearly black when ripe, one-third to one-half inch in diameter, with flesh thin, acid and rather astringent, scarcely edible. This is sometimes planted in parks to cover rocky banks.

APPALACHIAN CHERRY. *Prunus cuneata* Raf.

This differs from the preceding in uprightness of habit, in larger flowers and in leaf relatively shorter and broader with a more rounded apex. It has been found in Vermont in only a few places on sandy soils in the vicinity of Burlington.

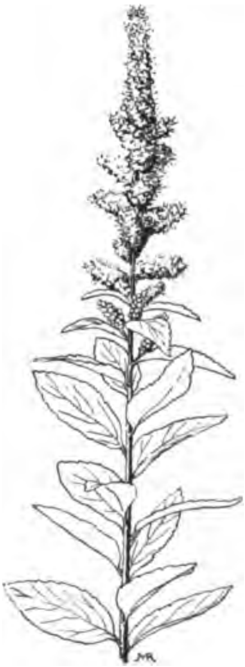
HARDHACK. SPIRAEA.

This name "hardhack" is applied rather loosely to several plants in Vermont, but to most New England farmers it suggests the commonest of the shrubby pasture weeds, also known as steeple-bush. There are two native species of spiraea growing intermingled and scarcely distinguished in the popular mind. Both come under the opprobrious name of hardhack, so that for differentiation in Vermont the names steeple-bush and meadow-sweet serve best. The Siberian spiraea (*Sorbaria sorbifolia*) with its large showy panicles of white flowers and mountain-ash-like leaves is frequent about old gardens and will probably be recognized in most cases without a key. The two native species may be at once distinguished as follows:

Young shoots and lower leaf surfaces rusty downy.......	**Steeple-bush.**
Shoots and leaves nearly or quite smooth..............	**Meadow sweet.**

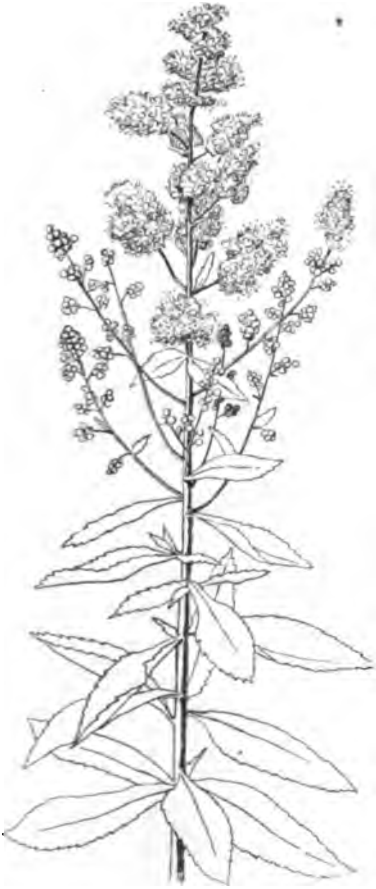
STEEPLE-BUSH. *Spiraea tomentosa* L.

This is so familiar that reference to the illustration, to avoid possible error in usage of the name, is all that is needed. Every Vermonter knows its characteristics. Wherever there is a neglected wayside or pasture, especially in the moister spots, the steeple bush soon raises its spire-like flower clusters. When in fresh bloom its delicate rose tints contrasting with the dark green foliage are pleasing to one who can forget its weedy aggressiveness. A few years ago the alarming increase of this shrub in rocky pastures, formerly so productive, was a cause of much regret to thrifty farmers. Today it is realized that the hard-hack spires are often an emblem of hope, pointing to the better days soon to come when, under wise encouragement, nature is to reforest these rocky lands with spruce and pine, the noblest and most profitable crops that can be grown upon them. Darlington says that the steeple-bush was, on account of its astringency, formerly considerably used in domestic medicines in New England. Its day as a medicine is probably largely past, but it is so attractive a shrub that it is sure to become more valued for use in ornamental planting. It is sometimes called woolly spiraea in contrast with the species figured and described on the opposite page.



STEEPLE-BUSH.
In flower, × ½.

MEADOW SWEET. *Spiraea latifolia* Borkh. L. (*S. salicifolia* L. of earlier botanies.)

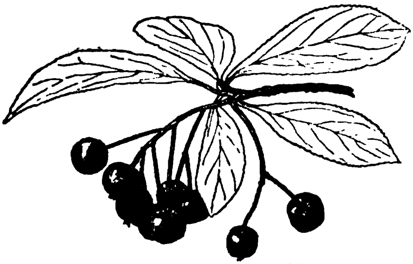


Flowering stem, × ½.
MEADOW-SWEET.

This is also termed the smooth spiraea; sometimes still more complimentary names are given it,—quaker-lady and queen-of the meadow. The farmers, even, will use a softer name than for the other, since this stays closer by swamps and wet ground less valued for pasture. It is somewhat taller and more branching than the preceding with larger and more open cluster of white or pinkish flowers. It is less striking but more delicate than the steeple-bush for landscape effects.

Introduced species. There are a large number of shrubby spiraeas which are hardy in this climate and offered for sale by nurserymen. The bridal wreath (*Spiraea Van Houttei*) is the most showy of these and frequent in cultivation. Others which are often planted are *Spiraea Japonica* (or *callosa*) *S. prunifolia* and *S. Thunbergii.* All have come from Asiatic ancestors.

CHOKEBERRY. *Pyrus arbutifolia* (L) L. f.



CHOKEBERRY, × ½.

There are two species of the chokeberry in Vermont. Blanchard has found in Windham county the typical red chokeberry (*Pyrus arbutifolia*) with quite showy red fruits which may adorn the branches even through the winter. The common plant in swamps, throughout the state is the

BLACK CHOKEBERRY. *Pyrus melanocarpa* (Mx.) Willd.

This is a shrub generally three to six feet high but may exceed that size. In general characters it is like the preceding species with upright habit and dark green rather handsome foliage. The leaves of this species are nearly smooth throughout, whereas the other is hairy below. The fruit in this black chokeberry is larger (one-fourth to one-third of an inch) in diameter and of shining black color. The berries are sweetish but too astringent to permit eating and no use is made of this shrub except for its sparing use in ornamental planting. Occasionally, either by mistake or otherwise, the berries are collected and sold as a huckleberry.

SERVICE-BERRY. AMELANCHIER.

The common June-berry or shad, often called sugar-plum, is typically a tree and treated in "Trees of Vermont." As there stated it ranges in size from a small tree to a shrub so the cut from that bulletin is here reproduced. The shrubby varieties and species resemble it in their abundance of white blossoms in early spring, with sweet edible red or purple berries, ripening in June or early July. All of the service berries produce attractive fruits which are promptly eaten by the birds. It seems possible that by selection and culture varieties desirable for the fruit garden may some day be produced.

SERVICEBERRY.
Leaves, flowers and fruit, × ⅛.
(From Trees of Vermont, p. 68).

Two things — aside from their small size— which preclude more general use of the wild berries at present are their irregularity in time of ripening and the promptness of the birds in harvesting them. The shrubby shad-bushes may be distinguished by the following characters:

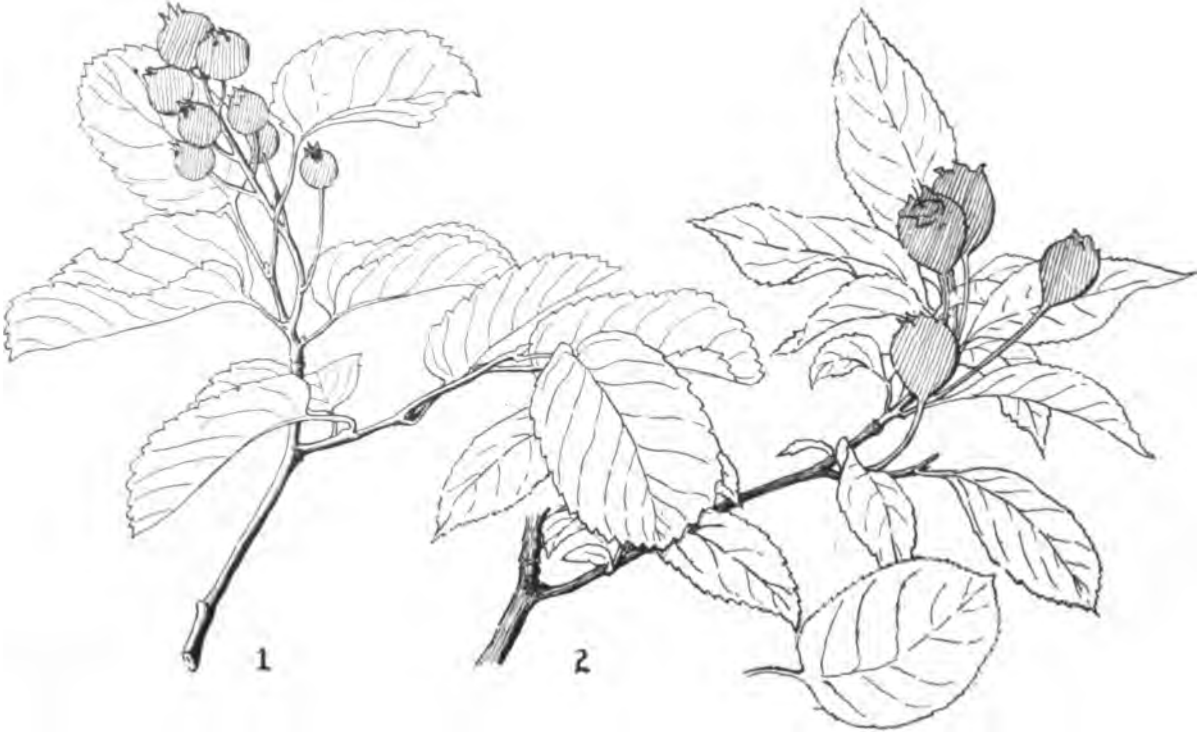
1. **Flowers 1-4, leaves acute at base, fruit pear-shaped or ellipsoidal**
Mountain shadbush.
1. **Flowers 5 to many, leaves obtuse or cordate at base, fruit globose 2**
2. **Leaves finely serrate or entire, flowers early in May.**
Early or rock shadbush.
2. **Leaves coarsely serrate, flowers 2 weeks or more later.**
Late or shore shadbush.

ROCK SHAD-BUSH. *Amelanchier oblongifolia* (T. & G.) Roem.

This species is more commonly found as a small low shrub in rocky woods, although it sometimes occurs several feet high. The young leaves and racemes are densely white hairy; the leaves are oblong, rounded at the ends; and the fruit is ripe in June and July.

SHORE SHAD-BUSH. *Amelanchier spicata* (Lam.) Koch. (*A. rotundifolia* Roem.)

This shrub is sometimes 10 or 12 feet high and is of more northern range than is the last. It is commonly found on rocky shores. This is the late-flowering and fruiting shad, with coarsely toothed leaves. It fruits from August to September.



1, **Shore Shadbush**; 2, **Mountain Shadbush**, × ⅔.
The unnumbered leaf in the lower right hand corner is that of the Rock Shadbush.

MOUNTAIN SHAD-BUSH. *Amelanchier oligocarpa* (Michx.) Roem.

This is the common shad-bush of the higher altitudes of the Green Mountains and is easily distinguished by the few flowers, the pear-shaped larger fruit and the acute leaves.

A form, *A. arguta* Nutt., with ellipsoidal fruit and smaller leaves is found occasionally in the lowland swamps.

The fruits of these species are less desirable than those of the previously named species.

CINQUEFOIL. POTENTILLA.

The cinquefoils or five-fingers are mostly herbaceous weeds. Two shrubby species occur in Vermont, however, one of them becoming rather too familiar in some sections. They are plants of quite different type as shown by the following characters:

Height 2 to 4 feet; compound leaf of 5 to 7 leaflets; flowers yellow ....Shrubby cinquefoil
Height 6 inches or less; leaf compounded of 3 leaflets; flowers white ....Three-toothed cinquefoil.

SHRUBBY CINQUEFOIL.[1] *Potentilla fruticosa.* L.

This is a low, much-branched, spreading bush, with bark scaling from the older stems, leaves a grayish green from the coating of silky hairs, and abundant conspicuous yellow flowers as bright and nearly as large as buttercup blossoms. It was originally found only occasionally bordering swamps and in a few cool, rocky gorges or cliffs. During the last generation however, it has been spreading persistently over the pastures in certain sections until today it must be ranked as the most aggressive invader among the shrubby weeds, quite outclassing the hardhacks. It is worst in the vicinity of Manchester and Dorset but extends northward to Salisbury and southward along the

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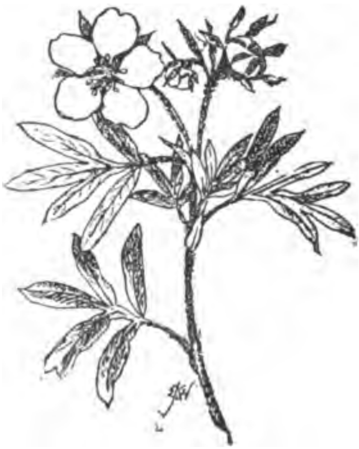
[1] For a detailed account of the shrubby cinquefoil as a weed in Vermont, see Vt. Sta. Rpt. 16, p. 173 (1903).

Taconic range, through Massachusetts and Connecticut. It is difficult to understand why it is less aggressive elsewhere unless it be because of its preference for lime which abounds in the section indicated. Plowing and close pasturing have been used successfully to check its progress. There is apparently so extreme an antipathy between this plant and the butternut that wherever the butternut tree gets started the shrub must perish. This suggests the possibility of exterminating the cinquefoil by planting butternuts. Reforestation of any kind, however, will soon suppress it. Wherever it has not become a serious pest farmers should take warning and keep it out. It has been given a variety of local names, Manchester weed, prairie-weed, yellow hardhack, sage-brush, etc. This shrub occurs also in Europe and it may surprise some farmers who have too much of it to know that as introduced from Europe through the nursery trade it has been rather frequently sold in Vermont for ornamental planting. It is an attractive shrub and there is no evidence that it has ever spread in such cases.



SHRUBBY CINQUEFOIL, × ½.

THREE-TOOTHED CINQUEFOIL. *Potentilla tridentata* Ait.

This is a rather rare plant found along the rocky summits of several of the Vermont mountains and higher foothills. It has a shrubby base but the shoots never rise more than a few inches. Each of the leaflets ends in three teeth, whence the name. The white flowers, less than one-half inch across, are borne in a rather pretty small terminal cluster. It is an attractive plant for use in rockeries.

RASPBERRY, BLACKBERRY AND DEWBERRY. RUBUS.

The raspberries and blackberries supply some of the finest and most abundant of the wild fruit of Vermont. These with the dewberries belong to the genus *Rubus*. It will conduce to clearness sharply to segregate in one's mind the members of the two fundamental groups of this genus as follows:

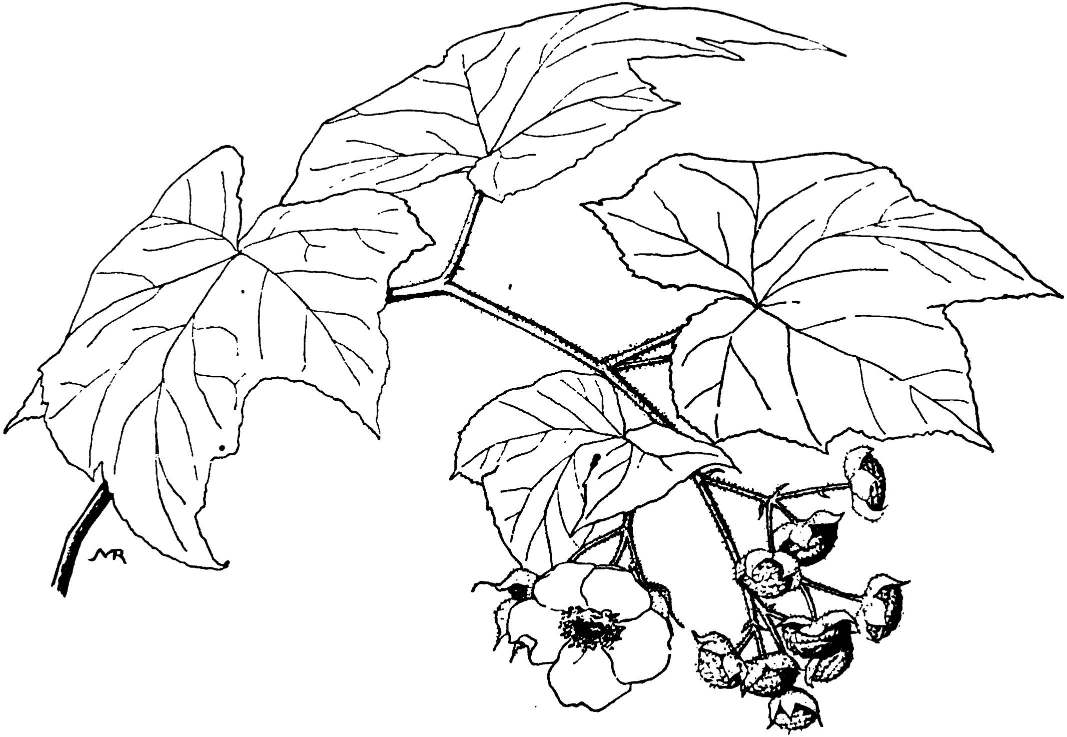
The thimble-shaped fruit or "berry" separable from the receptacle or "core" when ripe ....Raspberries.

The fruit or "berry" firmly attached to the end of the fruit stem or receptacle which remains as a "core" in the mature fruit.
Blackberries and dewberries.
(See key to these, page 108).

RASPBERRIES.

1. Leaves simple, flowers large, rose-like in color and form.
Flowering raspberry.
1. Leaves compound, flowers smaller, white 2
2. Fruit red, stems bristly, without whitish bloom, stoloniferous (i. e. spreading by underground stems) ....Red raspberry.
2. Fruit black, stems prickly, with whitish bloom (glaucous), rooting at apex ....Black raspberry.

These three species of raspberry are so well known and easily distinguishable as to call for an apology for the insertion of the above key, except for two matters which contribute to confusion of ideas. The first is the popular misuse of the name "mulberry" for the flowering rasberry in Vermont. It is to be hoped that this publication may contribute to the correct usage of these words. The second is, that where the black and red raspberries grow intermingled, they may hybridize. As a result the berry picker occasionally finds a "purple-cane berry" which is neither red nor black, but clearly a cross between the two. This species, *Rubus neglectus* of the botanies, has the stem, branches and tipping habit of the black raspberry, with prickles of the red raspberry, and purplish red fruit which is firmer than the red raspberry and has something of the black raspberry taste. In the garden several improved forms of this are in cultivation e. g. the Shaffer.



FLOWERING RASPBERRY. Blossom and young fruit, × ½.

On the limestone ledges of Cavendish there occurs an interesting native form of the European raspberry, (*Rubus idaeus* L. var. *anomalus* Arrh.)

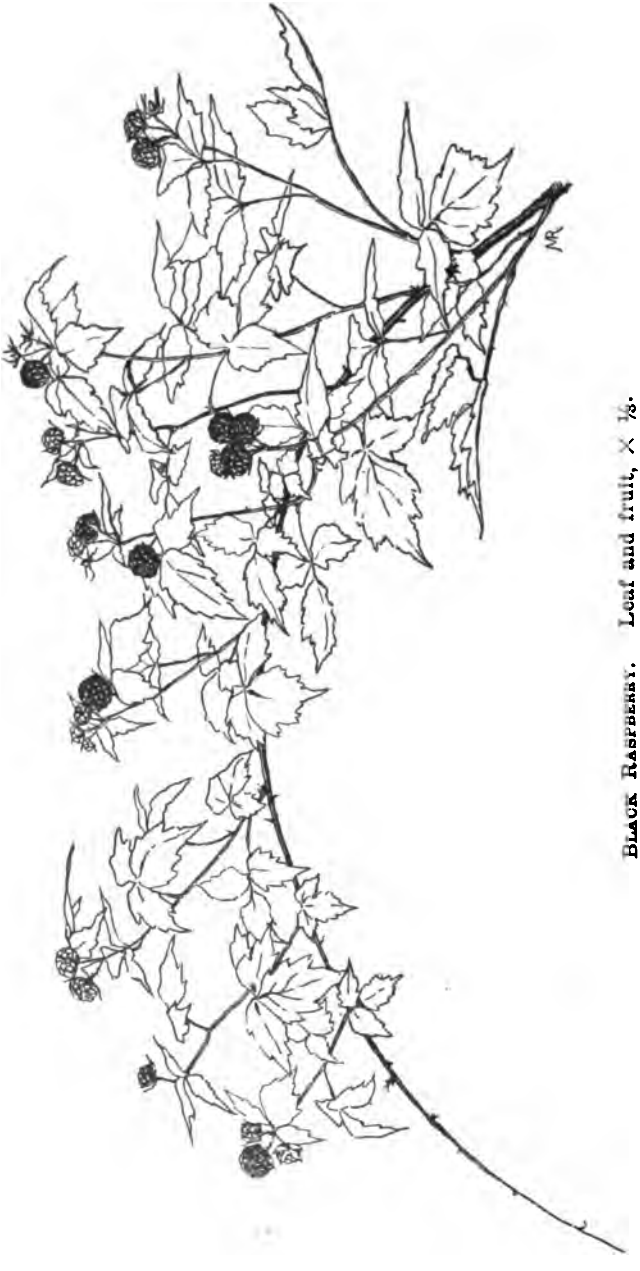
The red dewberry is sometimes mistakenly called dwarf raspberry, but is here placed with the dewberries where it more properly belongs.

FLOWERING RASPBERRY. *Rubus odoratus* L.

The flowering raspberry is also known as thimbleberry and erroneously as "mulberry." The true mulberry is a tree and occurs native in Vermont only very rarely in Pownal. The flowering raspberry is easily distinguishable from all of the others by its large purple flowers, maple-like leaves, and its very broad fruit. The fruit is used but little, although it is edible and some people are fond of it. It is well worthy of a place in the hardy shrubbery used for ornamental purposes, but has been thus utilized but little as yet in Vermont although listed in horticultural catalogues.

RED RASPBERRY. *Rubus strigosus* Mx.

The red raspberry is abundant all over the state, but one needs to visit a recent mountain clearing to find the fruit in perfection as to size and flavor. In contrast with the black, the red raspberry is stoloniferous, that is it sends creeping underground stems from the parent plant in all directions and thus quickly forms its characteristic thickets in woodland clearings. However, this raspberry needs no introduction to a Vermonter. Great quantities of the wild fruit are annually picked in the state, and we have no more delicious fruit whether fresh or preserved. For home canning it is especially popular since no native berry keeps the natural flavor so well as the red raspberry. One of the "goodies," the compounding of which is in danger of becoming a lost art in Vermont, is the red raspberries dried with maple sugar. This confection, as well as sweet flag preserved in maple sugar were hard things for the Vermont mother of the last generation to keep hidden in the house when her boys were at home.



BLACK RASPBERRY. Leaf and fruit, × ⅓.

BLACK RASPBERRY. *Rubus occidentalis* L.

This is found in the lower altitudes but never as abundantly as is the red raspberry. It always occurs in separate clusters or "bushes," while the red raspberry, as explained above, usually forms colonies of indefinite size. The plants are often in proximity, however, partly due to the fact that they tend to reproduce themselves fully as much by rooting at the tips as by seed. The long arching canes are very graceful.

BLACKBERRIES AND DEWBERRIES.

This group is especially to be commended to the systematic botanist who is seeking problems.[1] Of course everyone recognizes a blackberry bush at sight, and most would be sure of it upon contact even in the dark; but it requires an expert botanist to identify all of the so-called species of blackberries found in Vermont. About a dozen of those listed in the Gray's New Manual of Botany occur here, several of which have been so recently described that their distribution and botanical status are matters of doubt. Unquestionably some of these are hybrids between the older and more well marked species. It will be necessary to await continued observation of these doubtful forms, and probably to grow them from seed and to study their behavior in successive generations, before the final word is said as to their traits as well as regards their status. Herein lie problems in the solution of which local students may participate. With these facts in mind the writers have selected only the following common and clearly marked species for detailed consideration.

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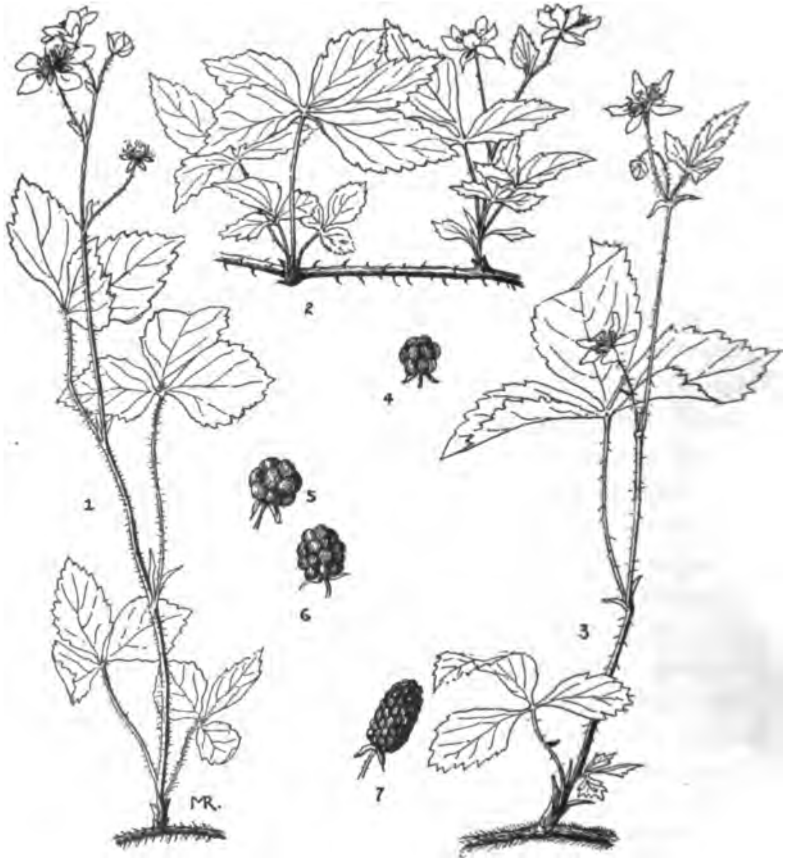
[1] One who is trying to acquaint himself with the details of the Vermont blackberry problems from the standpoint of systematic botany, should first consult Gray's New Manual of Botany. Both Mr. W. H. Blanchard of Westminster and Dr. Ezra Brainerd of Middlebury have done much work on our Vermont blackberries, and either one will freely answer inquiries, identify specimens, or direct to the further literature of this group.

BLACKBERRY-DEWBERRY KEY.

1. Fruit bright red when ripe, stem trailing, only slightly woody. Red dewberry.
1. Fruit black or reddish black when ripe, stem woody............2
2. Canes erect or ascending, with the longer canes often recurved..5
2. Canes trailing 3



DEWBERRIES AND BLACKBERRIES, × ½.

Flowering branches: 1, Swamp Dewberry; 2, Black Dewberry; 3, Bristly Dewberry (*R. setosus*). Fruits: 4, Swamp Dewberry; 5, Black Dewberry; 6, Mountain Blackberry; 7, Highbush Blackberry.

3. Stalks (pedicels) of flowers and fruit unarmed..................4

3. Stalks of flowers and fruit armed with sharp bristle-like prickles.
Bristly dewberry.

4. Fruit small, reddish-black; leaflets three, thick shining.
Swamp dewberry.

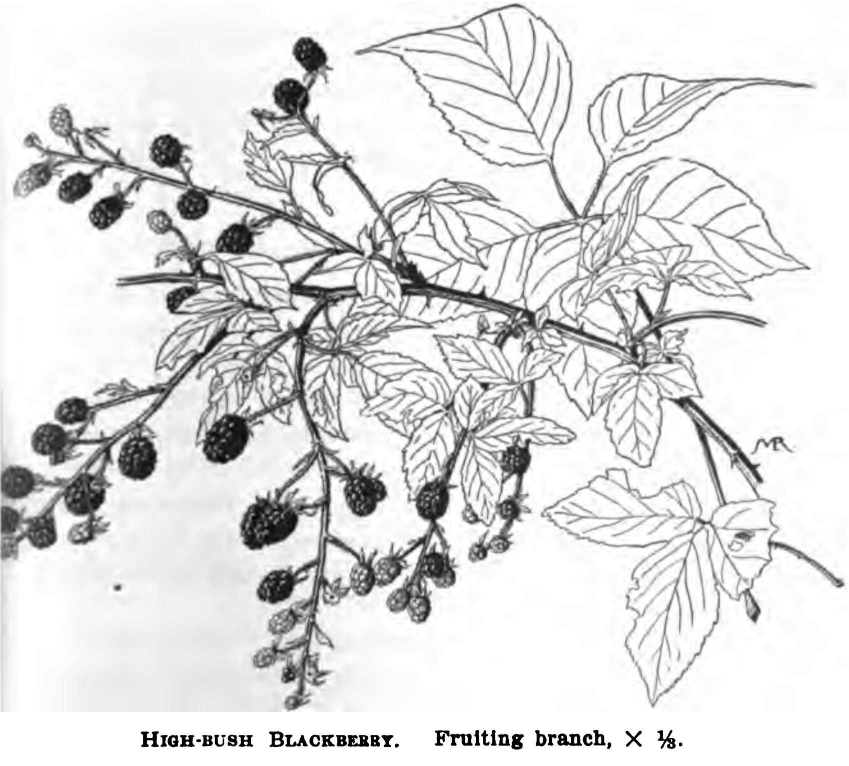
4. Fruit larger, black; leaflets 3 to 5, larger, thin, dull.
Black dewberry.

5. Stems (pedicels) of flowers and fruit covered with glandular hairs ....Highbush blackberry.

5. Stems of flowers and fruit glandless 6

6. Canes armed, recurved, often rooting at tips; lower surface of leaves downy ....Recurved blackberry.

6. Canes usually unarmed, erect; lower surface usually smooth.
Mountain blackberry.



HIGH-BUSH BLACKBERRY. Fruiting branch, × ⅓.

HIGH-BUSH BLACKBERRY. *Rubus allegheniensis* Porter (*R. nigrobaccus* Bailey.)

This is the common blackberry to most Vermonters, especially prevalent at lower altitudes. Like the red raspberry it is at its best in a new clearing where its tall sharply armed canes make impenetrable thickets. It requires a constant supply of moisture and partial shade for its finest development; and no fruit suffers worse if a drought occurs after the berries are set. Those who are used to the sweet, juicy, spicy, long-tapering wild blackberry of the new clearings feel poorly served by the sour, seedy market berry. Surely there is still plenty of work for the horticulturist among the blackberries.

RECURVED BLACKBERRY. *Rubus recurvans* Blanchard.

This is frequently found and easily recognized by its recurved stems, often rooting at the tip. The fruit is rather short with numerous large, juicy drupelets.

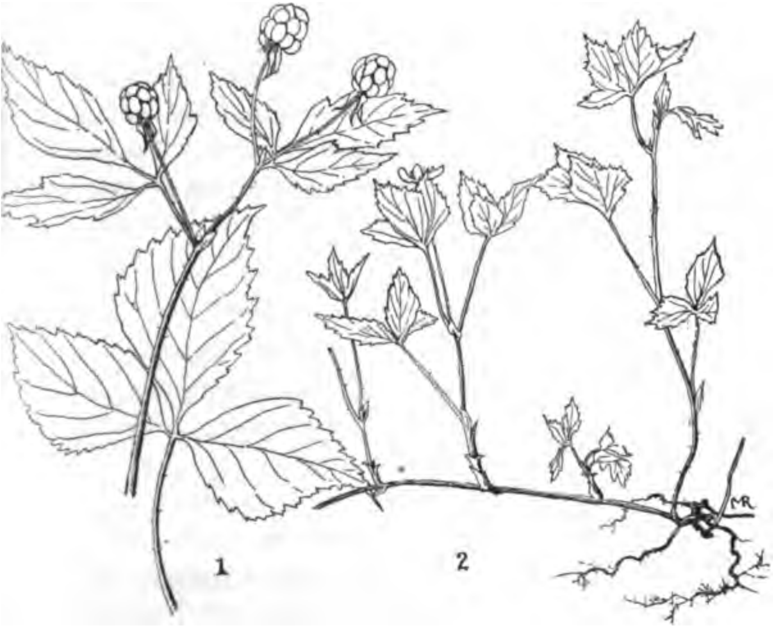
MOUNTAIN BLACKBERRY. *Rubus canadensis* L.

The mountain blackberry is the common berry of the higher altitudes (above 1500 ft.) and is even a more vigorous grower than the highbush blackberry of the lower valleys. It is easily distinguished from the latter by its usually smooth canes and smooth leaflets, shorter, sour berries with large drupelets borne in short clusters.

Another blackberry, *Rubus elegantulus* Blanchard, closely allied to the above has slender prickles on the angles of the canes, rather small leaflets in threes, and slender flower clusters.

RED DEWBERRY. *Rubus triflorus* Richard.

This is frequently known as running raspberry and is a very common trailer in our cold swamps and mountain woods. It is one of our most distinct species, differing in fruit from the dewberries by the red color. Although the drupelets adhere tenaciously to it, the receptacle never becomes edible.



RED DEWBERRY.
1, Leaf and fruit, × ½; 2, Flowering plant, × ¼.

BRISTLY DEWBERRY. *Rubus vermontanus* Blanchard. (*R. nigricans* Gray's New Man.).

These plants of the wet mountain woods and cold swamps are easily recognized by their ascending habit and very bristly canes. The berries are rather inferior to those of the mountain blackberry.

Rubus setosus Bigelow is similar to the bristly dewberry, but has very glandular pedicels and sepals while the former is usually glandless. This is much less common than the bristly dewberry (*R. vermontanus.*)

BLACK DEWBERRY. *Rubus villosus* L.

This species occurs in sandy soil in similar locations to the white pine and is more abundant farther south. It is readily recognized by its trailing habit, five thin leaflets, one to four flowers in the cluster, and round, large druped, sweet berries.

SWAMP DEWBERRY. *Rubus hispidus* L.

This pretty trailing vine of the lowland swamps is easily know by the dark-green, shining, thick leaves with three leaflets which usually remain green throughout the winter. The berries are very small and sour.

THE CULTIVATED BERRIES.

These berries are esteemed more highly for their fruit in this country than in Europe. The European red raspberry has long been cultivated in that country and was early introduced into the United States, but it has been practically driven out by the American cultivated berry, which is more hardy and ripens its fruit in a shorter time. The Cuthbert is one of the leading American red raspberries. The black raspberry is even more important commercially than the red, since it is dried very extensively. The Ohio and the Gregg are standard cultivated forms of the black raspberry. The Shaefer and the Gladstone are supposed to have sprung from the hybrid, *Rubus neglectus*.

The blackberries and dewberries are an American product, the first cultivated blackberry, the Dorchester, being produced in 1841. Some of the best varieties have been evolved from the high-bush blackberry and its allied forms. Here belong the long-cluster blackberries, Taylor and Ancient Briton, the short cluster blackberries, Snyder, Kittatinny, Erie, etc., and the leafy-cluster blackberries, Early Harvest, etc.

Forms of the black dewberry have given us the Lucretia and the Bartel, while the intermediate strain between the high-bush and the black dewberry, usually known as *R. heterophyllus* Willd, has produced the Wilson, Wilson Jr., and Rathburn. While much has been done in improving our native blackberries and raspberries, much more remains to be accomplished, for although the cultivated forms are productive and larger than the wild fruit, still they lack flavor and have much larger seeds.

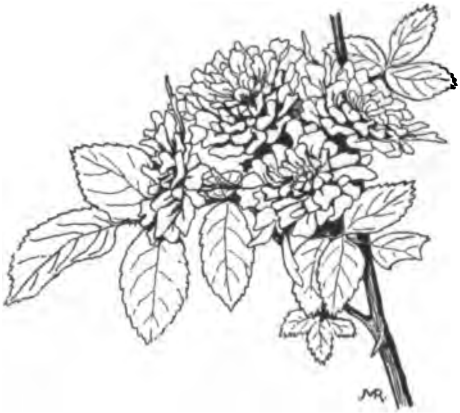
THE ROSES. ROSA.

Everyone recognizes a rose-bush, even when in the leafless stage, but few—and trained botanists are not always reckoned among these few—can distinguish all of our native species at sight. While this is not always of primary importance, it is worth while with so conspicuous and favorite a flower to know how many kinds may be expected in one's neighborhood, somewhat of their season and natural habitat, whether the particular plant which is under survey is a June rose like the cinnamon or perchance may be of midsummer habit like the swamp rose, whether to be sought by the water side as the swamp rose, or on the dry ridges as the pasture rose, and whether native like the smooth rose or of European ancestry like the sweetbrier. Bearing in mind these characteristics and the others mentioned below we may easily add to the charm of our acquaintance with the wayside rose, the pleasure in most cases of calling it by its own proper name.

1. **Flowers single** 2
1. **Flowers more or less doubled, (introduced species).**
Cinnamon rose.
2. **Foliage aromatic (sweet-scented) prickles numerous and recurved** ....**Sweetbrier**.
2. **Foliage not sweet-scented** 3
3. **Sepals erected after flowering, persistent; surface of fruit and fruit-stalk (pedicel) smooth and stem with few or no prickles** ....**Smooth** rose.
3. **Sepals spreading after flowering, falling off from the mature fruit, surface of fruit and fruit-stalk bristly or hairy, stem with prickles** 4
4. **Stipules narrowly linear, leaflets finely saw-toothed (usually on low moist soil)** ....**Swamp** rose.
4. **Stipules dilated, leaflets coarsely toothed (usually on dry soil).**
Pasture rose.

THE CINNAMON ROSE. *Rosa cinnamomea* L.

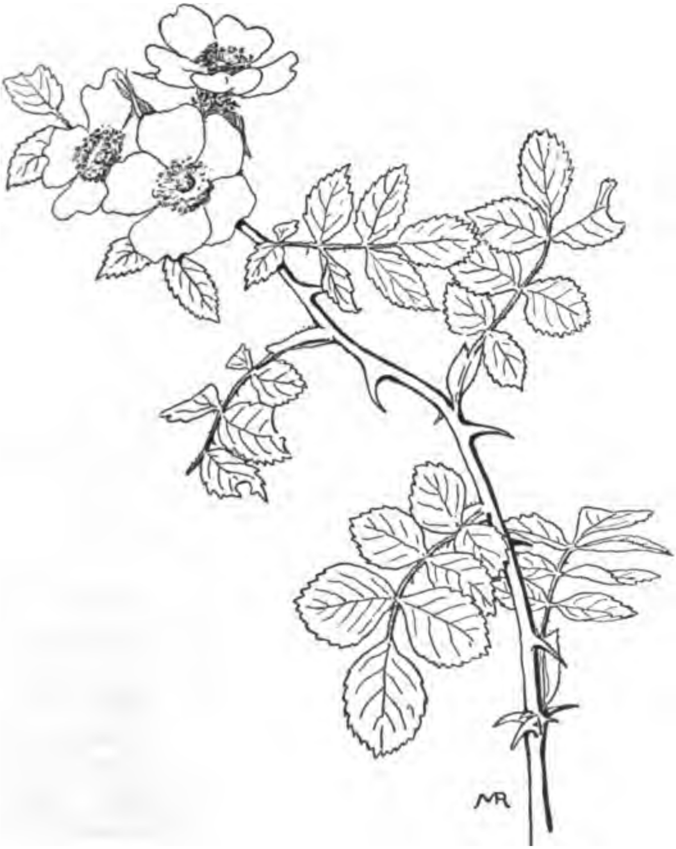
Everyone is familiar with this homely old fashioned pink rose. The constancy of its presence about the abandoned homes of the early mountain side clearings is an almost pathetic reminder of how our grandmothers must have carried the roots as precious memories from the gardens of their childhood homes when they invaded the wilderness. It is so fully doubled that it seems rarely if ever to spread from seed, but once established the roots send up new shoots year by year, suppressing the unsightly docks and tansy which our herb-drinking ancestors alalways introduced along with it.



CINNAMON ROSE, × ½.

THE SWEETBRIER. *Rosa rubiginosa* L.

No plant in all our flora bears a more appropriate name than the sweetbrier, with its combination of strong needle-pointed, hooked prickles, and the spicy fragrance of its foliage. This is evident to the sensitive nostril even when some distance away, but when crushed between the fingers is unmistakably suggestive of the fragrance of a highly scented apple. It must have been for this, coupled with its glossy green, that it was brought



SWEETBRIER.
Flowering branch, × ½.

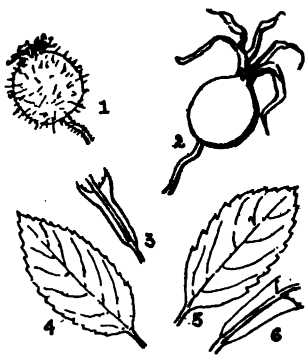
from Europe into the early New England gardens, for the flowers although pretty are scarcely more attractive than some of our natives. This is sometimes called "Eglantine," although that name more properly belongs to another closely related European species. Being a normal fertile blossom it seeds abundantly, and as a result it has become so frequent in rocky pastures near old homesteads as to be almost a characteristic of them. The mossy galls so often found on the branches are caused by the sting of an insect.

THE SWAMP ROSE. *Rosa carolina* L.

When one comes upon a characteristic colony of this rose in full blossom occupying the front ranks of a water-side thicket, its profusion of pink flowers banked against the dark green of alder and the varnished sprays of the shining willow, or the sheen of the rarer silky willow leaves, it is a picture for long memory. Although either of our other native species may occur in moist soil, this is the one which is characteristically at home along the borders of swamps and streams. This fact, and the further one that the stems are usually tall, often shoulder high, make its general recognition easy.

THE PASTURE ROSE. *Rosa humilis* Marsh.

This is the most common wild rose of Vermont pastures and waysides. Its characteristic habitat is dry soil or rocky slopes. The stems are usually low, one to three feet high, slender, armed with straight slender prickles. The pink flowers of this and the other two natives are so similar in size and general appearance that one must turn for careful differentiation to less conspicuous characters. Those of leaf margins and stipules



1, PASTURE ROSE, fruit;
2, SMOOTH ROSE, fruit;
3, 4, SWAMP R., stipules and leaflet;
5, 6, PASTURE R., ditto. All × ⅝.

serve to separate this form from the swamp rose as shown in the figures and emphasized in the preceding key. The sepals are most useful for distinguishing this species from the next. In addition to the characters emphasized in the key one should note that the outer sepals of the pasture rose are always more or less lobed.

THE SMOOTH ROSE. *Rosa blanda* Ait.

While less generally common in Vermont than the pasture rose, the smooth rose is frequent especially on rocky headlands and banks of lakes and streams. The stems are low, generally one to three feet, although they may rise somewhat higher than the pasture rose. The branches typically are nearly or quite unarmed, but occasional plants occur with numerous prickles. The smooth surface of the hip and the sepals connivent after the flowering stage, and persisting even upon the mature fruit, enable ready recognition as explained in the key. To distinguish this form from the pasture rose it may suffice to note that the sepals have entire margins and are not lobed as are the former.

In addition to the above list of the commoner roses several other native kinds occur occasionally. The most widely distributed of these is the prickly rose, *Rosa acicularis* Lindl. var. *Bourgeauiana* Crepin. This is most closely allied to the smooth rose, differing in the abundance of its long slender prickles and its bristly leaf stem. This is occasionally found on the dry headlands and rocky ridges of western Vermont. Two others have been found so rarely that one who suspects he has them should refer to some manual of botany, or submit specimens to an authority. The glossy rose, *Rosa virginiana* Mill. has been found in two places, North Pownal and Stratton Pond. The so-called "northeastern" or bristly rose, *Rosa nitida* Willd., has been found only at Bradford.

THE CULTIVATED ROSES.

There are so many kinds of rose in cultivation that only an expert can hope to know them all or to understand their relationships. The sweet brier and the cinnamon rose are so commonly escaped that they are described in detail above. The Gallic or French rose, *Rosa gallica* L. is a low bristly-glandular plant with handsome dark green leaves and fine red flowers, often semi-double, which has occasionally escaped from old gardens to roadsides. The Scotch rose (*Rosa spinosissima* L.) is often cultivated and may become naturalized near houses. The finest of the double roses of garden and greenhouse are either of the damask type (*R. damascena*) or the India or China rose (*R. indica*). The hybrid roses are of these two; the tea roses are of the latter type. The eglantine rose (*R. eglanteria*) is an old fashioned rose with fragrant foliage, resembling the sweet brier. The Japanese rose (*R. rugosa*) is a more recent introduction but rapidly gaining favor because of its rich foliage. Recently the crimson and other ramblers and other clustered roses of the *multiflora* group have been given especial attention. Since they are quite hardy and very attractive and new hybirds are appearing each year, there is much to be hoped for them as additions to the rose garden.

THE THORNAPPLES. CRATAEGUS[1]

This group of plants is best developed in the limestone areas of western Vermont, particularly about Lake Champlain and its tributaries. Occasionally in the Green Mountains they reach an altitude of 2,200 feet, and *Crataegus Kennedyi* Sarg. is known only on the summit of Willoughby Mountain, at about 2,500 feet.

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[1] Owing to the complexity of the various forms of thornapple, especially in the Champlain valley, it has been necessary either to pass by the group with only a general characterization, or else to make the account more technical than is the balance of this bulletin. The above carefully prepared account of the groups by Mr. Eggleston has been accepted as the best method of treatment under these circumstances.

L. R. J.

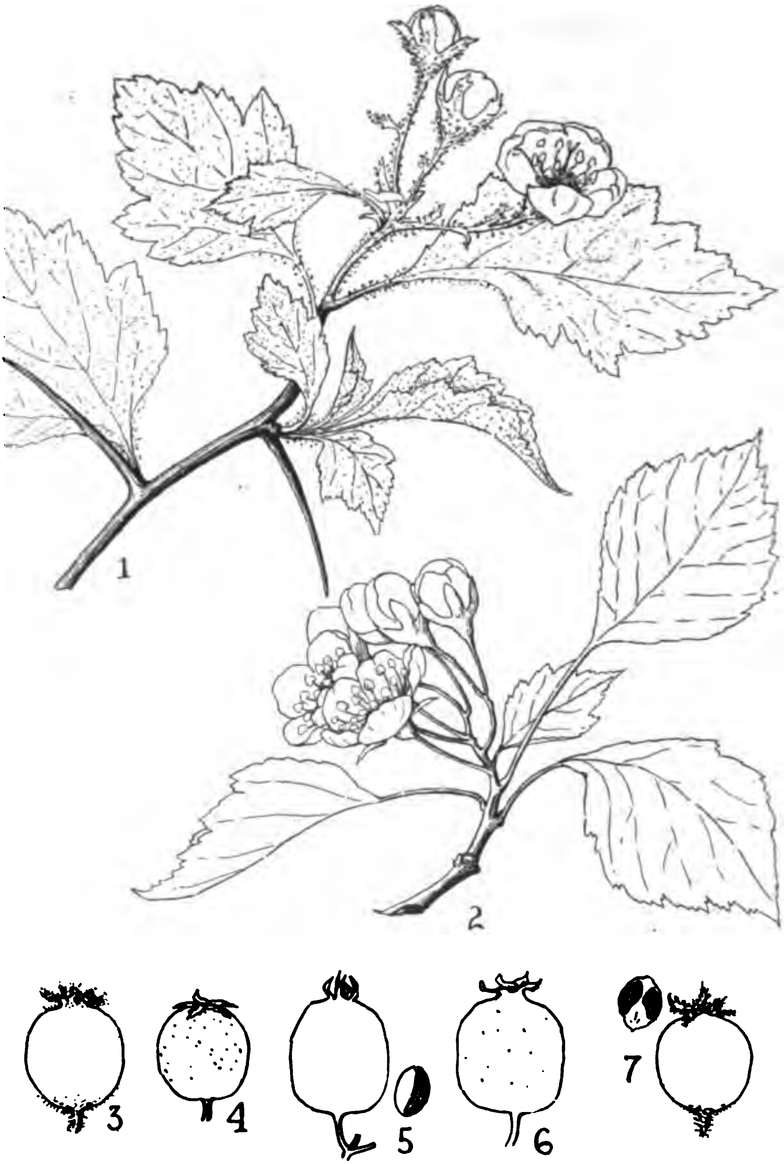
Of the ten groups found in Vermont, four are trees and the others are usually large shrubs, although all of them but the Intricatae may occasionally produce a small shrubby tree. This variable genus is not as yet well understood. Although many species have been described, much good work may yet be done in our field to further the study of the thorns. For the purpose of this work it seemed best to give only a short account of the groups. If one cares to go farther he will find in Rhodora, in the Botanical Gazette and in the New Gray's Manual much information which will be pertinent. It should be noted that the following account deals only with the smaller or shrubby species.

Key to the groups of shrubby species. based on fruiting characters.

1. **Nutlets pitted on the inner surface 2**
1. **Nutlets plain on the inner surface 3**
2. **Nutlets deeply pitted ....Macracanthae.**
2. **Nutlets with shallow pits ....Anomalae.**
3. **Fruit hard at maturity 4**
3. **Fruit soft at maturity 5**
4. **Fruit waxy, petioles smooth ....Pruinosae.**
4. **Fruit not waxy, petioles wtih stalked glands...........Intricatae.**
5. **Fruit ellipsoidal ....Tenuifoliae**
5. **Fruit globose ....Rotundifoliae.**

Key to the group of shrubby species based on flowering stage.

1. **Calyx lobes entire or nearly so 2**
1. **Calyx lobes serrate 3**
2. **Leaves yellow-green slightly hairy, flowers 1½—2 cm. wide, anthers, pink ....Tenuifoliae.**
2. **Leaves blue-green, smooth, flowers about 2 cm. wide, anthers light pink ....Pruinosae.**
3. **Calyx lobes serrate 4**
3. **Calyx lobes deeply serrate 5**
4. **Calyx lobes more prominently toothed towards the apex, petioles with stalked glands ....Intricatae.**
4. **Calyx lobes equally toothed throughout length, petioles without stalked glands ....Rotundifoliae.**
5. **Leaves dark green and shining above, rather thick, veins somewhat impressed ....Macracanthae.**
5. **Leaves lighter, thinner, veins not impressed...........Anomalae.**



THORNAPPLES. Natural size.
Flowering branches: 1, *Crataegus coccinea;* 2, *Crataegus pruinosa.* Fruits: 3, *Crataegus coccinea*; 4, *Crataegus rotundifolia*; 5, *Crataegus macrosperma* (fruit and nutlet); 6, *Crataegus pruinosa*; 7, *Crataegus macracantha* (fruit and nutlet).

The Intricatae represent a southern group that reaches its northern limit in central Vermont. It has few-flowered corymbs and yellow-green young foliage, both of which are very glandular, stamens usually ten, anthers light yellow. The leaves are elliptical-ovate, acute at both ends, subcoriaceous, the petioles bearing stalked glands. The fruit matures very late, being hard when it falls in October, of a greenish yellow or reddish yellow hue, and globose or short pear-shaped containing three or four nutlets. The shrubs are two to six feet with few thorns. Two species are known in Vermont, *C. apposita* Sarg. and *C. intricata* Lange (*C. coccinea* of the newer edition of Gray's Manual), while one other *C. foetida* Ashe has been reported from the Connecticut valley.

The Rotundifoliae range farther north than any other eastern group and seem well at home in Vermont. The young foliage is yellow-green, corymbs many-flowered, stamens five to twenty, anthers light yellow, leaves elliptical-ovate to orbicular, subcoriaceous, shining above, fruit red, globose, the flesh softening before it falls, ripening from August to October, nutlets three or four. The shrubs are five to fifteen feet high with numerous thorns. *C. Kennedyi* Sarg., *C. Oakesiana* Eggl., *C. irrasa* var *Blanchardi* (Sarg.) Eggl., *C. rotundifolia* Moench., and var *Faxoni* (Sarg.) Eggl., constitute the rotundifoliae of Vermont.

The Tenuifoliae are the most abundant and the most puzzling of our Vermont groups. The young foliage is bronze-green, slightly hairy, the corymbs many flowered, stamens five to twenty, anthers pink, leaves ovate, acute, doubly serrate. The petioles are long and slender. The fruit which matures from August to October, is red, ellipsoidal, calyx erect and slender, flesh soft, the nutlets three to four in number. The shrubs are six to twenty feet high with numerous curved thorns. The following species are known in Vermont: *C. lucorum* var. *insolens* (Sarg.) Eggl., *C. roanensis* Ashe., *C. alnorum* Sarg., *C. macrosperma* Ashe., *C. m.* var. *pentandra* (Sarg.) Eggl., *C. m.* var. *demissa* (Sarg.) Eggl., *C. m.* var. *pastorum* (Sarg.) Eggl., and *C. m.* var. *matura* (Sarg.) Eggl.

The Pruinosae are difficult to distinguish from the Tenuifoliae unless one has the mature fruit. In general the flowers are larger, the anthers lighter red and the foliage smoother, with a tendency toward blue-green rather than yellow. The fruit is waxy, angular or globose, the calyx lobes are raised up and thickened at the base, and the flesh is hard when the apples fall in October. The nutlets are usually four or five. The shrubs are six to twenty feet high with numerous thorns. The species in Vermont are: *C. pruinosa* (Wendl.) C. Koch., *C. p.* var. *philadelphica* (Sarg.) Eggl., *C. p.* var. *dissona* (Sarg.) Eggl., *C. Beckwithae* Sarg., and *C. Jesupi* Sarg.

The Macracanthae are one of our most distinct groups being sharply characterized by nutlets with pits on the inner faces, deeply serrated calyx lobes, and dark green impress-veined, leathery leaves. The fruit softens in September, is red, globose and usually contains two or three nutlets, the flesh being quite characteristic having a glutinous feeling. The plants of this group more often become trees than the others, being from six to twenty-five feet in height and with numerous long sharp thorns. The following species occur in Vermont: *C. macracantha* Loddiges, *C. m.* var. *succulenta* (Schrad) Eggl., and *C. m.* var. *neofluvialis* (Ashe) Eggl.

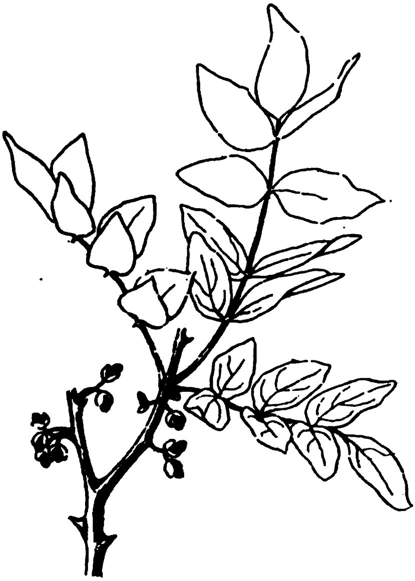
The Anomalae are well named as they are our hardest group to separate. The writer holds that *C. Brainerdi* Sarg. and its varieties *Egglestoni,* (Sarg.) Rob., *scabrida* (Sarg.) Eggl., and *asperifolia* (Sarg.) Eggl. must have originated as crosses between the Macracanthae and perhaps some of the Tenuifoliae: but they certainly are well established species now, for there are numerous mountain pastures in Vermont where hundreds of the variety *Egglestoni* are found, and the others are nearly as frequent and as well marked in various localities. The Anomalae have thinner, less shiny leaves and calyx lobes less cut than the Macracanthae, while the pits of the nutlets are shallow and the flesh is not glutinous.

RUE FAMILY. RUTACEAE

This is an interesting family of plants, chiefly trees and shrubs, including the citrus fruits, orange and lemon, the fraxinella of old-fashioned gardens and the garden rue from which comes the family name. This rue was probably more commonly cultivated formerly than now and it has established itself in at least one place (Weybridge) as a garden escape. The leaves or other parts are characterized by transparent dots which contain a pungent aromatic oil. Only one representative occurs in Vermont.

THE PRICKLY-ASH. *Xanthoxylum americanum* Mill.

This is a shrub of three to eight feet usually forming thickets on rocky woods and banks. It is frequent in portions of the Champlain valley. This is readily recognized by its prickly stem and strongly aromatic bark and leaves, the latter being compound, somewhat like the ash only smaller, hence the name. The American Indians used the prickly ash as a medicine and it became one of the popular home remedies of the herb-doctors of the early settlements, an infusion of the bark being used for ulcerous wounds, rheumatism, colic, etc. The bark was sometimes chewed as a remedy for toothache, and it is therefore sometimes known as the toothache-tree. One who has recently tried it says that it excites the flow of saliva and drives away the toothache, at least temporarily, but that the taste of the bark is scarcely less disagreeable than the ache it relieves.



PRICKLY ASH.
Fruiting twig, × ½.

CROWBERRY FAMILY. EMPETRACEAE

BLACK CROWBERRY. HEATH-BERRY. *Empetrum nigrum* L.

This is a prostrate, heath-like, evergreen, alpine shrub with black berries found in the moist, peaty soil on the summits of Mount Mansfield and Camel's Hump. The evergreen leaves are very small, less than one-fourth of an inch in diameter. The fruit is said to be a favorite food of the mountain birds.

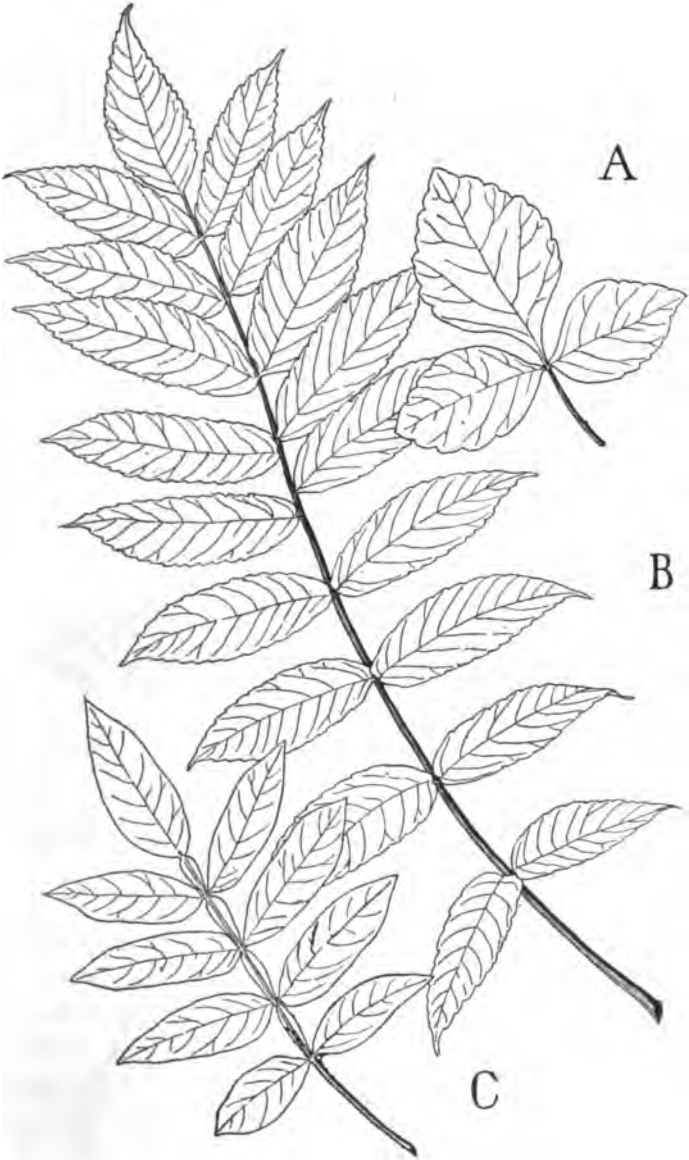
SUMACH FAMILY. ANACARDIACEAE

This is an interesting family of plants, mainly tropical. Several species have a resinous juice which thickens upon exposure and furnishes the finest of oriental varnishes, including those most prized from Japan and China. All of these are, however, related to our own poison ivy and, like that, may be poisonous to the skin of certain persons. The cashew and pistachio nuts and the mango fruit are also valuable products from oriental members of this family. As it occurs in Vermont it is represented by but one genus.

THE SUMACHS. RHUS.

These are among our most familiar shrubs. The several species may be distinguished as follows:

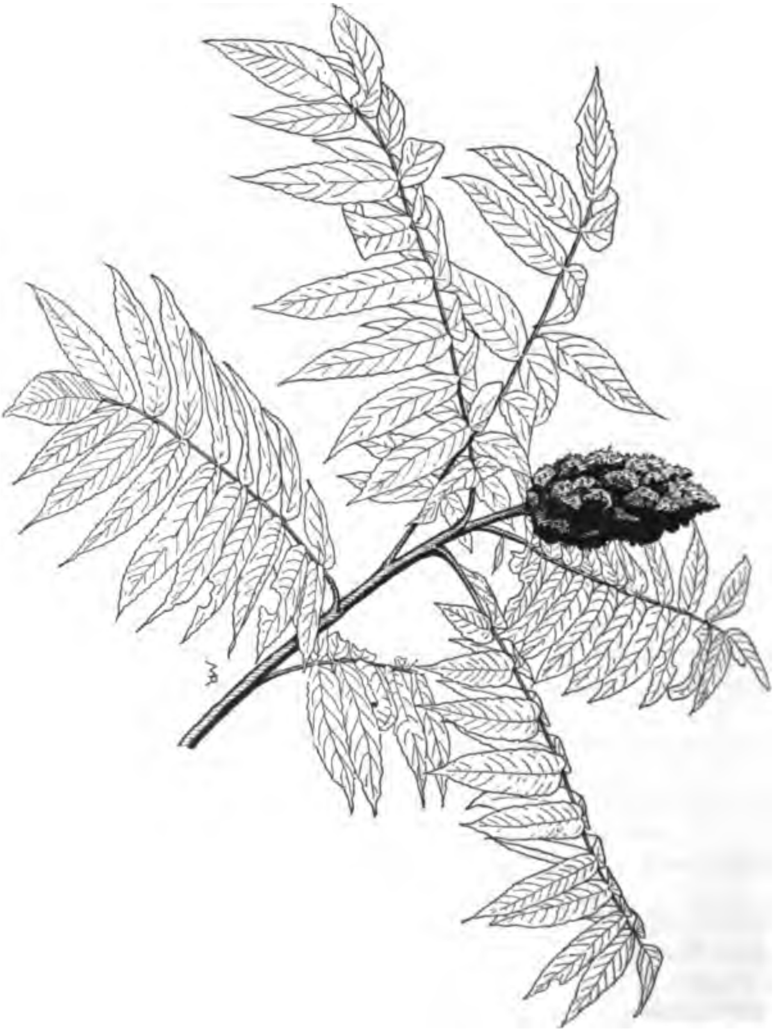
1. Flowers and fruit in compact clusters at the end of branches, fruit reddish and hairy, plants not poisonous to the touch, (the true sumachs) 2
1. Flowers and fruit in loose clusters in the leaf axils, fruit whitish and smooth, plants poisonous, (the poison sumachs)........5
2. Leaves compounded of three leaflets............Fragrant sumach.
2. Leaves compounded of seven or more leaflets 3
3. Petioles winged or margined ....Dwarf sumach.
3. Petioles not winged or margined 4
4. Branches and leaf-stalks velvety-hairy...........Staghorn sumach.
4. Branches and leaf-stalks smooth ....Smooth sumach.
5. Leaves compounded of three leaflets ....Poison ivy.
5. Leaves compounded of 7 to 13 leaflets ....Poison sumach.



A, FRAGRANT SUMACH; **B, SMOOTH SUMACH;**
C, DWARF SUMACH, × ½.

STAGHORN SUMACH. *Rhus typhina* L.

This is the common sumach of Vermont, forming thickets everywhere by waysides and in old fields. While usually developing as a shrub of ten feet or less when in thickets, it may



STAGHORN SUMACH.
Fruiting branch, × ⅛.

assume the habit and size of a small tree when standing alone. The farmer must often rate the sumach as a nuisance because of its invasion of his pastures and the persistence with which, following cutting, it will sprout from the root. The lover of the wayside, however, must prize the grace and beautiful tints of the sumach foliage and the richer color of its fruits in autumn and winter. The sumachs are indeed among the best of native shrubs for ornamental planting. In selecting plants the fertile or fruit-bearing ones should usually be chosen. A finely cut-leaved form is obtainable from nurserymen. The leaves and the bark, which are rich in tannin, were formerly used in tanning, and a medicine for fever has been prepared from the root.

SMOOTH SUMACH. *Rhus glabra* L.

This is quite as handsome a shrub as the staghorn and is preferable for ornamental planting. It does not grow quite so large and has a more spreading irregular habit. It occurs only rarely in northern Vermont but is common in the Hoosac and Southern Connecticut valleys. A cut-leaved form of this species is also found in the trade. The leaves were formerly used for tanning and the berries, because of their acidity, were employed as a substitute for lemon juice in various domestic practices and in the preparation of home remedies. The berries are used in dyeing, an infusion being said to furnish an unequalled black dye for wool.

DWARF SUMACH. *Rhus copallina* L.

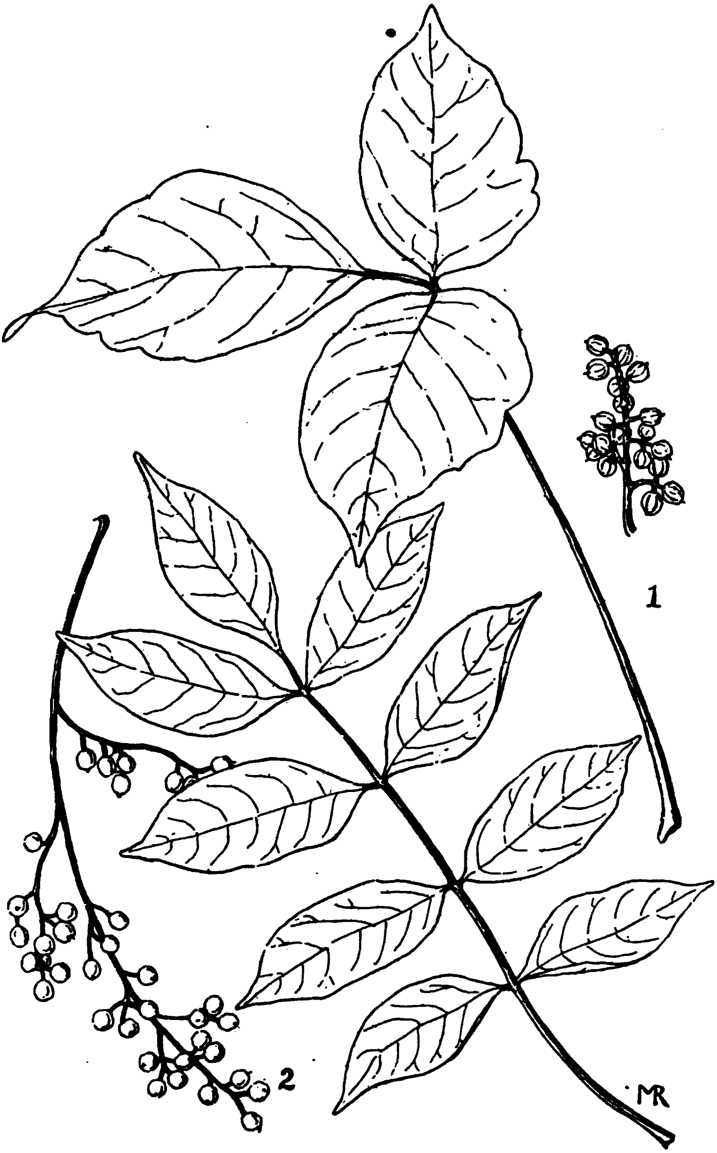
This as its name implies is a lower shrub than either of the above mentioned. It is frequent in Vermont in dry or sandy soil and is easily recognized by the winged margins of the leaf stalks. Its value for ornamental planting is on a par with the staghorn or smooth species. Its leaves are quite as rich in tannin, and large quantities are collected in the south for tanning leather. The Indians were fond of admixing dwarf or smooth sumach leaves with their smoking tobacco.

FRAGRANT SUMACH. *Rhus canadensis* Marsh. (*R aromatica* Ait.)

This is a low straggling shrub, usually two to four feet high, which occurs only occasionally on rocky banks in western Vermont. It is of considerable value in ornamental planting in rocky soil, but otherwise is of less economic interest than the other sumachs. Its popular name was suggested by the fact that the leaves, especially when bruised, are slightly aromatic.

POISON IVY. *Rhus toxicodendron* L.

The poison ivy, or three-leaved ivy, is sometimes given the confusing name of poison oak. It is common, especially in moist woodlands and fence rows, and is so dangerous a plant that every school child should learn to recognize it. This is easily done by noting the characters of leaf and fruit. The leaflets are always in threes, with the end leaflet slightly stalked, as shown in the figure. In size and toothing they have a general resemblance to the common woodbine or five-leaved ivy. The number of leaflets is, however, a sure distinction. The poison ivy is distinguishable from other three-leaved woodland plants by its woody stem and climbing habit. Its dry, greenish-white berries, the size of small peas, standing in grape-like clusters, are also a conspicuous character of the older plants. In the matter of climbing, however, the plant may vary so widely as to puzzle botanists. It may stand as a low upright shrub if it has nothing to cling to, but usually it develops as a low vine, climbing by rooting stems over old stumps and walls. If well started at the base of a living tree it may, however, climb to indefinite height, rooting itself in the bark and injuring the tree as well as menacing human passers-by. Some persons are severely poisoned by the slightest contact with this shrub, while others handle it with impunity. Even the latter may well shun it, however, since if once poisoned they will thereafter remain susceptible. The poison resides in a resinous exudate on the sur-



1, **POISON IVY**; 2, **POISON SUMACH**.
Leaf and fruit of each, × ½.

face of the plant, and, according to our best authorities, it is transmitted only by contact, i. e. not blown through the air. In many cases especially susceptible persons are probably unwittingly poisoned by getting it on their shoes or clothing and, later, poisoning their hands by contact with these. Most persons are especially liable to the poison when perspiring freely. After wandering in proximity to the plant at such a time, it is a wise precaution thoroughly to wash hands and face with free use of strong soap or, much better, with washing soda or some other strongly alkaline solution, which will remove the poison before it has time to strike in. If too late for this, the best remedy is to bathe the parts freely with some of these alkaline washes. A solution of sugar of lead in alcohol is one of the best. Where the poison-ivy occurs near schools or dwellings, it should be exterminated. If in the open field this is easily done by digging it out. Often, however, it grows in stone walls among stunps, or so close to the base of a tree that it is difficult to get at the roots. In such cases a liberal application of a strong solution of washing soda will destroy it. A solution of arseniate of soda (1 pound in 8 gallons of water) is even more effective.

THE POISON SUMACH. *Rhus Vernix* L.

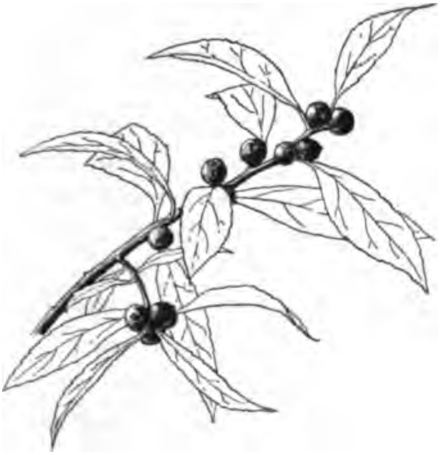
This also goes under a confusing variety of names, such as poison elder and poison dogwood. It likewise exudes a poison similar to the preceding and is fully as dangerous. This shrub grows to a height of six to fifteen feet. It is a swamp plant familiar to anyone who penetrates the swampy thickets bordering Lake Champlain. Fortunately it is not common in most parts of Vermont. It is the most graceful of the family, with brilliant autumn tints. Were it not so poisonous it would be highly prized as an ornamental shrub. The white berries resemble those of the commoner poison ivy but are borne in longer, looser clusters.

HOLLY FAMILY. ILICINAE

Many persons who are familiar with the name and appearance of the holly tree of Europe and the South do not know that there are two shrubs of this family in Vermont, the winterberry and the mountain holly. Although neither rivals the hollies just referred to for Christmas decorations, each is an attractive plant in its way and season.

WINTERBERRY. *Ilex verticillata* (L.) Gray.

This is also called the black alder, but should not be confused with the true alder (*Alnus*), or with the elder berries (*Sambucus*). It is a frequent shrub in moist thickets, of an upright habit, much branched, four to eight feet high, with grayish bark and dark green leaves, conspicuously veined and somewhat leathery. The southern holly is evergreen, but the leaves fall from our northern species in autumn. The berries, which ripen in September to a bright scarlet, are about one-fourth inch in diameter. They may form singly or in close clusters of two or three in the axils of the leaves, where they cling through the autumn and even in the winter may render the shrubs conspicuous and of ornamental value. Both the bark and berries have a decidedly bitter taste and were formerly used in home medicines for fevers. This species is somewhat variable, with one named variety in Vermont (var. *tenuifolia*).


WINTERBERRY.
Fruiting branch, × ½.

MOUNTAIN HOLLY. *Nemopanthus mucronata* (L.) Trelease (*N. fascicularis* Raf.)

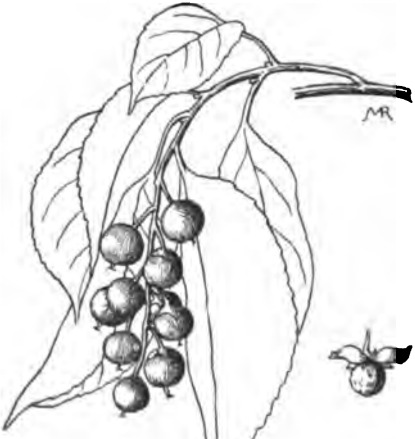
This is a frequent shrub in cool moist woods and swamps, somewhat taller than the last. It bears abundant crops of berries which are about one-fourth inch in diameter, ripening in mid-August to a beautiful dark crimson and making the bushes very showy. They are easily distinguished from the allied winter-berry by the fact that each berry is borne on a stalk an inch or more long, which is crimson like the fruit. The berries though not poisonous are more or less bitter and repugnant. It deserves a place in ornamental planting.

MOUNTAIN HOLLY, × 3/8.

STAFF TREE FAMILY. CELASTRACEAE

CLIMBING BITTERSWEET. STAFF-VINE. *Celastrus scandens* L.

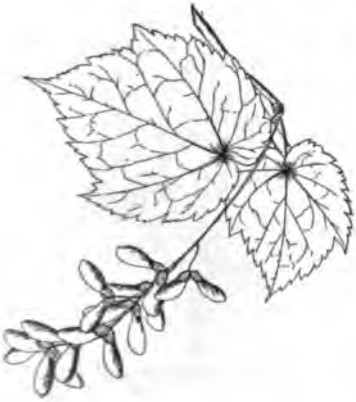
This is the only representative in Vermont of its family. It is the most elegant of the native vines, frequently found climbing over rocks and bushes and even ascending small trees to fifteen or twenty feet. Often it twines about other stems so closely as to deform them in curious ways. It prefers moist shady situations but it will grow almost anywhere. The leaf characters are shown in the drawing. The fruits are bright orange, nearly one-half inch in diameter and when mature in late autumn the outer part bursts to disclose the still brighter scarlet berry-like contents. These are in small cluster which, persisting into the winter, give a unique charm to this vine for ornamental planting as a cover for rockeries, arbors and piazzas. They may be cut in autumn and brought into the house for dry


CLIMBING BITTERSWEET. Fruiting branch, × 1/2.

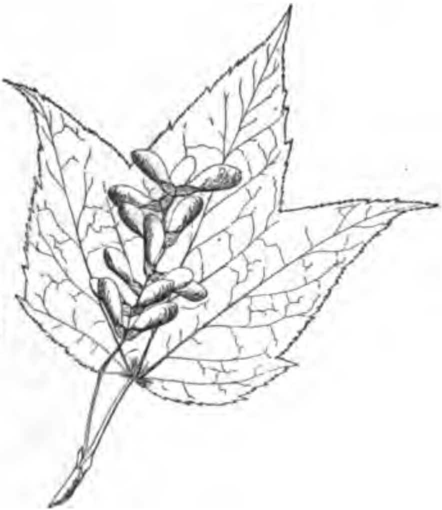
bouquets. The berries are non-poisonous but distasteful. Formerly they were used in compounding home remedies which were destined to "cleanse the blood" and act upon a torpid liver.

MAPLE FAMILY. SAPINDACEAE

The most familiar members of this family are trees and were described in the bulletin, "Trees of Vermont." Two of the maples, striped maple or whistle-wood and mountain maple, never grow large and are often shrubby in habit. Leaf cuts of these are therefore reproduced from the previous bulletin. There is another interesting member of this family which is always a shrub, i. e. the bladdernut.



MOUNTAIN MAPLE.
Leaves and fruit, × ⅛.

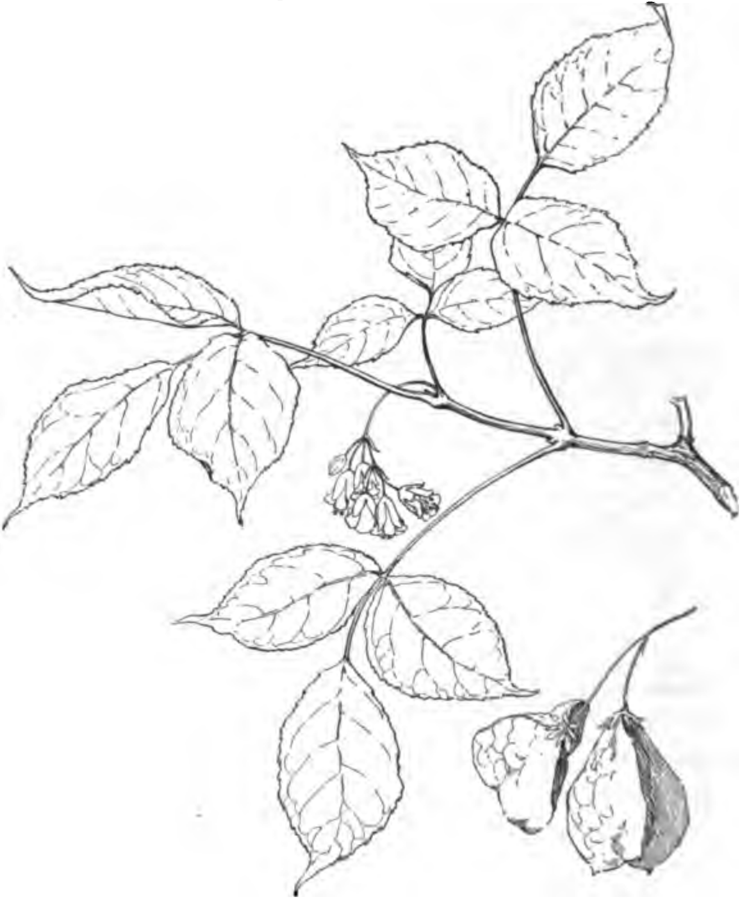


STRIPED MAPLE.
Leaf and fruit, × ⅛.

BLADDER-NUT. *Staphylea trifolia* L.

This shrub differs widely from the tree maples and, indeed, was formerly classed with the bittersweet in the preceding family. It is a handsome, upright, branching shrub of six to fifteen feet, found occasionally in moist woods and thickets. Its leaves are compounded of three leaflets somewhat resembling poison ivy.

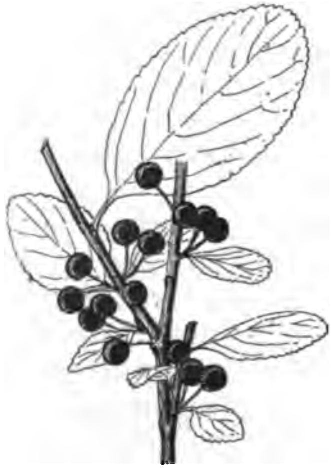
The character which will make its recognition sure, however, is the fruit. This is a triangular capsule one to two inches long, consisting of three papery-walled pods grown together. Usually the seeds in two of these pods are abortive, while that in the third is the size of a small pea. This may loosen as it ripens converting the pod into a curious natural rattlebox. The adaptation of this peculiarity of structure to the dissemination of the seed, whether through the agency of air or water, is evident.



BLADDER-NUT.
Flowering branch and fruit, × ½.

BUCKTHORN FAMILY. RHAMNACEAE

The buckthorn proper is a European tree or large shrub which is frequently planted and has sometimes escaped to Vermont waysides and so was described in "Trees of Vermont." A native buckthorn and two related shrubs further represent the family in our territory.



ALDER-LEAVED BUCKTHORN, × ½.

ALDER-LEAVED BUCKTHORN.

Rhamnus alnifolia L'Her.

The native buckthorn occurs rather frequently in cold swamps. It is a low shrub, reaching four or five feet in height and tending to grow in clumps. The leaf-form as shown in the sketch resembles that of the alder, whence its name. The flowers appear with the leaves in early spring, but are small and greenish, therefore scarcely noticeable. The fruit consists of berries about the size of peas, borne in clusters each on a stem about one-half inch long. These mature in midsummer when they become black and pulpy, more tempting in appearance than in flavor. No use has been made of this plant, although its European relatives yield both medicines and dyes.

CEANOTHUS

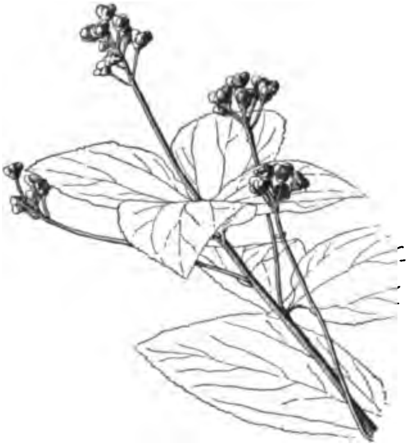
There are two species of *Ceanothus* in Vermont each of some interest, distinguishable as follows:

Branches and underside of leaves more or less downy, flowering in July, a common shrub of dry woodlands....New Jersey tea.

Branches and leaves smooth or nearly so, flowering in May, a rare shrub of the sandy bluffs of Lake Champlain.Smaller red root.

NEW JERSEY TEA. *Ceanothus americanus* L.

This is a common under-shrub in dry open woodlands, especially in somewhat sandy soil. The characters of its leaf and of the dry three-sided fruit are shown in the illustration. The small and white flowers hang in clusters at the end of a rather long stalk. Each flower in turn stands upon a white, thread-like stem. The leaves of this plant were used as a substitute for tea during the Revolution; hence its common name. It is also known as red-root because of the deep red color of the bark of the roots, which is said to be used in Canada to dye wool. It has mildly astringent qualities and has been used as a medicine.



NEW JERSEY TEA.
In fruit, × ½.

SMALLER RED-ROOT. *Ceanothus ovatus* Desf.

This is a similar shrub to the preceding, but of lower growth, smooth throughout and bearing shorter flower stalks. It is a rare shrub, confined to a small area of the sandy bluffs of Lake Champlain in Burlington Bay. It is of peculiar botanical interest since it is a plant typical rather of the western prairies and the shores of the Great Lakes, and because its presence on Champlain shores possibly dates from the time when this lake was an arm of the northern ocean and in closer relation with what is now the western lake region.

VINE FAMILY. VITACEAE

Th general likeness of our two representatives of this family, the grapes and Virginia creepers, would lead any close observer to class them together. They are vines climbing by compound tendrils which are borne opposite the leaves—a family mark—and all bear fruit of similar structure and appearance. The well marked difference is that the grapes have simple leaves while the Virginia creeper leaves are compounded of five leaflets.

THE GRAPES.

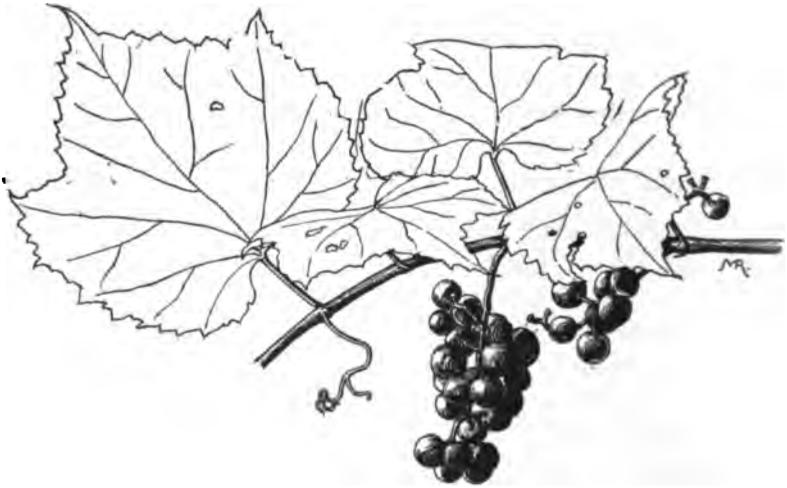
The grapes reach their best development in a warmer climate than this, yet in right locations in Vermont both the wild and certain cultivated varieties of grape flourish. When one recalls that the splendid European raisin and wine grapes, now so much grown in California with berries as large as small plums, originated from an Asiatic species having berries not larger than currants, and that all the grapes cultivated in eastern America have been produced within a century from wild American species, he may readily believe that in time hardier and better varieties, which will thrive and ripen anywhere in our territory, will be secured from American stock.

The three native wild species may be distinguished as follows:

1. Leaves densely rusty-woolly on under side............Fox grape.
1. Leaves not rusty woolly ....2.
2. Leaves pale or glaucous on under side..........Summer grape.
2. Leaves green on under side ....River grape.

RIVER GRAPE. *Vitis vulpina* L. (*V. riparia* Mx.)

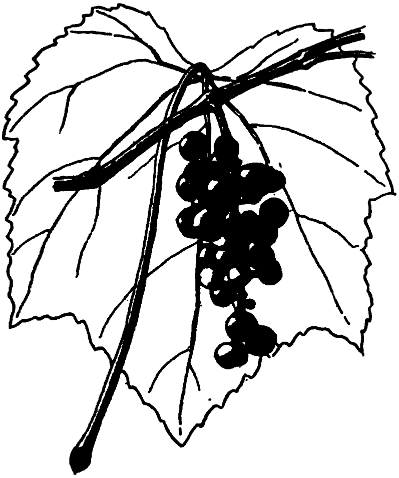
This is the commonest wild grape of Vermont. It passes under several common names; riverbank grape, from its favorite habitat; frost grape, from its late ripening which may come after the early frosts; sweet-scented grape, from the delightful fragrance of the flowers which open with the June roses. It will grow in a wide variety of soils and situations but is most at home along the banks of streams and in alluvial thickets. Here it climbs to any height necessary to reach the sunlight and bears abundant crops of small berries, about one-third of an inch in diameter. These vary widely in flavor from sour to fairly sweet, but are generally austere. The river grape is distinguishable from the summer grape both by leaf characters and by the later fruit which ripens with the autumn frosts. The foliage has a bright green cast, the leaves having a thin, broadly heart-shape depression at the base, more or less three-lobed or five-lobed, with sharply cut notches, smooth and bright green below except that the veins and their angles may be hairy. The leaf margins are variously toothed and cut, the teeth and the long terminal point of the leaf being sharply acute. The fruits are often gathered for preserves or for the juice. The Clinton and some other cultivated grapes are derived from this stock.



RIVER GRAPE, × ⅗.

SUMMER GRAPE. *Vitis bicolor* Le Conte.

The summer grape is frequent, especially in dry, gravelly soil and about the bases of cliffs. The berries ripen just before the frosts. They are small, one-half inch or less in diameter, with a dense bloom and of sour but pleasant flavor when ripe. The young canes usually, but not always, have a bluish or glaucous bloom. The leaves are rougher than the last owing to the deeper veining, and are a darker green above and lighter glaucous-blue below. The bluish bloom may, however, disappear from cane and leaf in the autumn. The leaves may be quite smooth or with scattering rusty hairs on the underside. The tendrils and leaf stalks are relatively long. The leaves on the younger growth are often deeply three-to-five-lobed with the base of the clefts rounded, those on the older growths shallowly three-lobed. The margins are almost entire, or have shallow and relatively dull teeth as compared with the river grape.



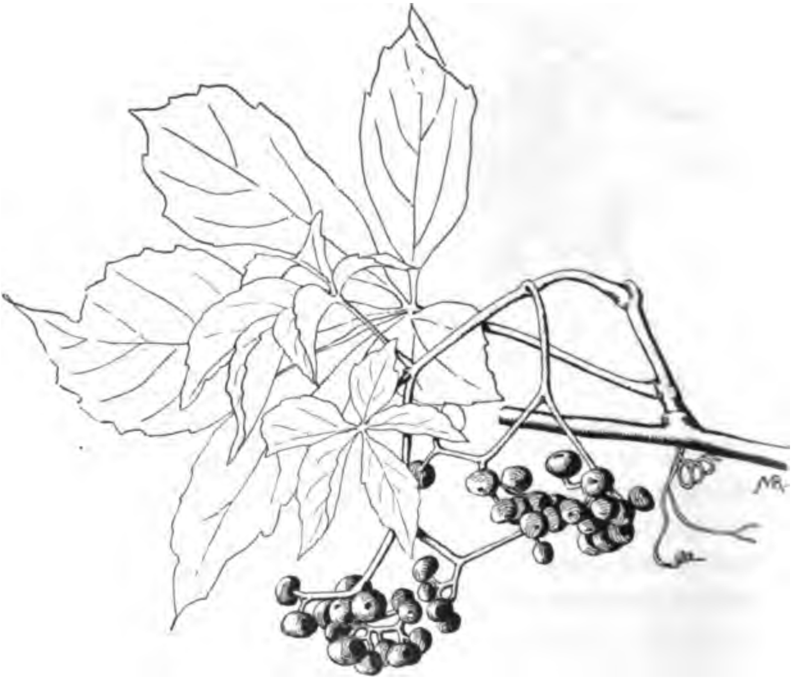
SUMMER GRAPE, × ½.

FOX GRAPE. *Vitis labrusca* L.

This is a grape found commonly from Massachusetts south and westward. It has been reported in Vermont only from Vernon. The leaves and young shoots of this grape are very cottony, and even the adult leaves retain the rusty wool beneath. The fruit is large usually with a tough musky pulp, but varying widely. From it by breeding and selection have come most of the cultivated American grapes, as for example the Concord.

THE VIRGINIA CREEPERS. AMERICAN IVY. PSEDERA. (AMPELOPSIS).

The Virginia creeper is the predominant vine of Vermont, everywhere clothing uncouth walls and fences with its green mantle and festooning decaying buildings and decrepit trees with its fresh sprays. It is sometimes known as woodbine, American ivy or five-leaved ivy. A glance at the illustration will serve to show its characters to anyone in doubt as to its identity. Its autumn colors add much to its charm, making it by all means the most useful vine for general ornamental planting in Vermont. It has long been observed that there are some differences between vines especially as to the clinging habits, and recently two species which occur in Vermont have been recognized and named.



VIRGINIA CREEPER.
Leaf and fruit of the smooth disk-creeper, × ½.

Since popular names have not been applied to these we have coined them as follows:

1. **Tendril branches twining, disks few or none....Tendril creeper.**
2. **Tendril branches mostly ending in adhesive disks. Disk-creeper.**

TENDRIL CREEPER. *Psedera vitacea* (Kneer) Greene.

This is the commonest form in Vermont, especially in wayside thickets and old fence rows. While usually clambering over low fences and thickets it may ascend tall trees, clinging to any available small support by the three to five slender twining branchlets of the non-disk-bearing tendrils. This is the creeper most commonly transplanted but either of the two disk forms is to be preferred for many situations. The tendril creeper has slightly larger leaves and fruit than the disk forms.

DISK-CREEPER. *Psedera quinquefolia* (L.) Greene.

When a vine is desired to climb the side of a house, wall, tree or similar surface, the disk-bearing varieties should be sought. The type or smooth one is frequent, ascending tree trunks in open woodlands. There is also a downy variety (var. *hirsuta*) which occurs especially about cliffs, where it may be seen ascending vertical walls of bare rock with no support other than its own disks. It often develops aerial rootlets which further aid it in climbing. Apparently it is not so common as either of the others and is said not to produce berries. Further observations are needed upon this and other matters concerning the distribution and characters of these creepers.

ROCK-ROSE FAMILY. CISTACEAE

BEACH-HEATHER. *Hudsonia tomentosa* Nutt.

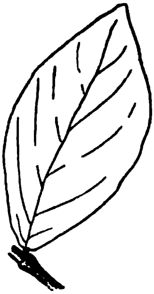
This plant is also known as the downy hudsonia. As its English name implies, this is a heather-like plant which is found only along the sandy beaches of Lake Champlain. So far as observed it is confined to the vicinity of Burlington bay and the sandy stretches just northward in the neighborhood of the mouth of the Winooski river. There it forms curious mound-shaped colonies, sometimes several feet across, which enlarge and elevate themselves year by year by dint of capturing the drifting sand in their meshwork of fine branches. The leaves are very small, scale-like, and grayish from the downy hairs, characters which are doubtless helpful in protecting them from sun and drought. In early summer an abundance of tiny yellow blossoms transform each tuft into a mound of gold. This plant, like the smaller red-root, is an interesting evidence of the relation of the Champlain flora to that of the sea shore and the Great Lakes, since it occurs nowhere else between these points.

MEZEREUM FAMILY. THYMELAEACEAE

This is a rather curious group of plants distinguished by a bark of great toughness and acridity. Two representatives are to be included for Vermont.

LEATHERWOOD. *Dirca palustris* L.

This is often called moosewood in Vermont. It is a low, much branched shrub of three to five feet in height, frequent in low moist woodlands. The pale greenish-yellow flowers, about one-half inch long, appear in early spring making the bush temporarily conspicuous, but they rapidly fade and fall as the leaves appear. The leaves are smooth and handsome, green above, pale and slightly downy beneath. The bark is the most remarkable development of its kind among our native plants. It is very thick and consists of long interlaced fibres of surprising strength. So tough is it that the united strength of two men will scarcely break the bark removed from a well developed



LEATHER WOOD, × ½

stem. It was used for thongs, ropes and basketry by the aborigines, and supplied bag strings for the millers and farmers of the early settlements. The plant was used by the Indians for its medicinal qualities, being chewed for toothache and possessing emetic properties.

Closely allied to this leatherwood is the

DAPHNE OR LADY LAUREL. *Daphne Mezereum* L.

This is a small, erect, garden shrub, with attractive lilac-purple flowers clinging closely to the twigs in earliest spring and, later, bearing clean handsome foliage. It has escaped from old gardens to rocky woodlands in a few places in the state (Burlington and Montpelier). Probably the seed is carried by birds feeding on the berries.

OLEASTER FAMILY. ELAEAGNACEAE

CANADIAN BUFFALO-BERRY. *Shepherdia canadensis* (L.) Nutt.

This family is closely allied to the preceding and like it has but the one native species in Vermont. This is a comparatively rare plant on the cliffs and headlands of the Champlain valley. It is characterized by the rusty appearance of the lower leaf surface, due to the abundant clothing of silver stellate hairs which are interesting as viewed under the microscope. The fruit, which is borne but sparingly, is a yellowish red, insipid berry. This plant is sometimes recommended for ornamental planting on dry rocky situations. It is, however, less used than is its close relative, the buffalo-berry of the western plains, which is valuable both for its silvery foliage and its edible fruit.

LOOSESTRIFE FAMILY. LYTHRACEAE

SWAMP LOOSESTRIFE. *Decodon verticillatus* (L) Ellg.

The members of this family are typically herbaceous, but one of the most attractive, the swamp loosestrife or water willow. *Decodon verticillatus* (L.) Ellg., is woody at the base and has the general appearance of a small shrub. It has lithe branches and long slender leaves, giving it a willow-like aspect. It chooses a similar habitat in the borders of swamps, or with its roots buried in a sphagnum bog. A glance at its opposite leaves serves, however, to differentiate it from the alternate-leaved willow twig, and its beautiful magenta blossoms add a glory to many a swamp in August. These have an added interest because of their three forms, which show remarkable adaptation to cross fertilization by insects. It is one of the most attractive plants for ornamental planting along streams or similar wet places.

DOGWOOD FAMILY. CORNACEAE

The name dogwood is misapplied to other shrubs in Vermont[1], which is the more unfortunate since there are seven native species of true dogwoods, including some of our commonest and handsomest shrubs. These are all characterized by having white or greenish-white four-parted flowers, which are individually rather small but are collected in conspicuous clusters. The fruit follows also in showy clusters of berries, the color and size varying with the species. The dogwoods bear a general resemblance to the arrowwoods or viburnums, described later in this pamphlet, from which the fruit will most readily serve to distinguish them. The stone of the viburnum berries is much flattened, one-celled and one-seeded; that of the dogwoods is oval, two-celled and two-seeded. It is also helpful to remember that all the dogwoods have entire leaf margins.

The several native species of dogwood are recognizable as follows:

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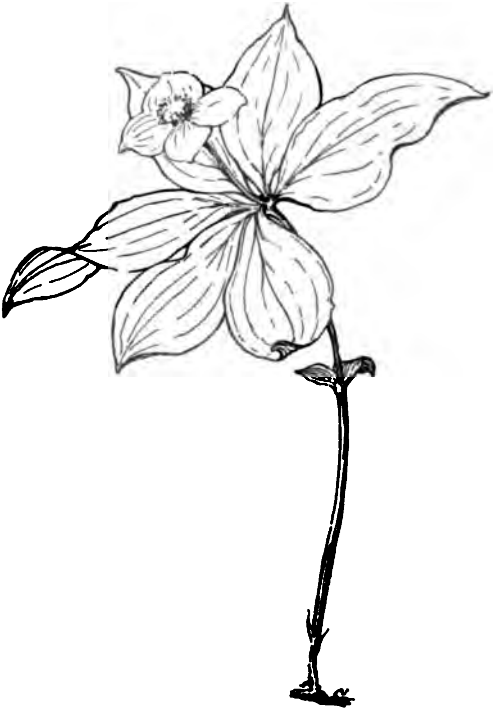
[1] The striped maple is often called striped dogwood; the poison sumach is also known as poison dogwood.

1. **Flowers in a close head, appearing like a single large blossom 1 to 3 inches across, with small greenish flowers in the center surrounded by four large petal-like white leaves (involucre); fruit bright red ....2.**
1. **Flowers white in a broad, flat, open, cluster; fruit white or blue ....3.**
2. **A large shrub or small tree of 10 to 30 feet. Flowering dogwood.**
2. **Small, less than 1 foot high........................Bunch-berry.**
3. **Leaves alternate........ ....Alternate-leaved dogwood.**
3. **Leaves opposite ....4.**
4. **Leaves broadly ovate (egg-shaped) often nearly round; fruit light blue ....Round-leaved dogwood.**
4. **Leaves narrower; fruit pale blue or blue-white ....5.**
5. **Twigs, leaf stalks and lower leaf-surfaces silky-downy, often rusty; fruit pale blue ....Silky dogwood.**
5. **Twigs smooth and leaves smooth or nearly so; fruit white or lead-color ....6.**
6. **Branches red or purplish, leaves rounded at base. Red-osier dogwood.**
6. **Branches gray, leaves tapering at base........Panicled dogwood.**

FLOWERING DOGWOOD. *Cornus florida* L.

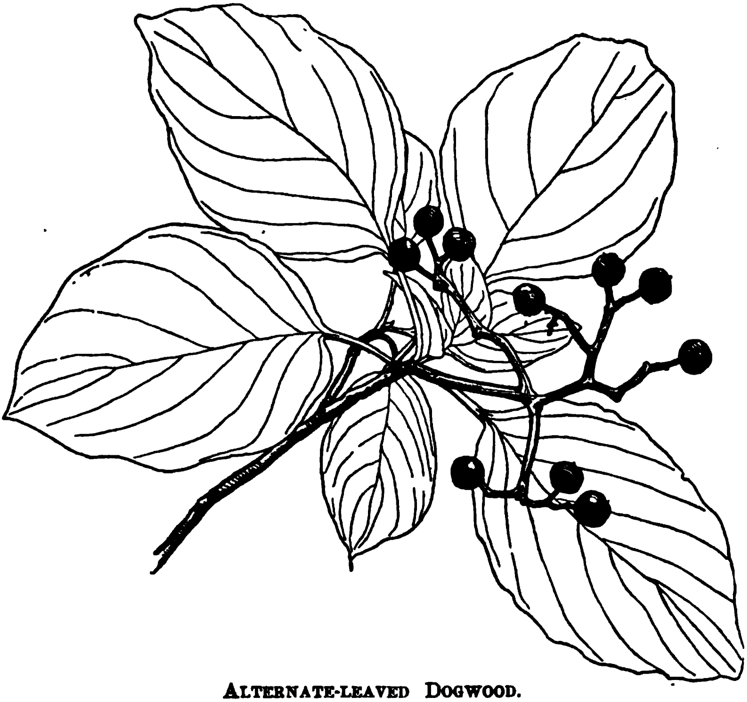
This is the most showy of the dogwoods and is known and famed for its beauty wherever it occurs. It is common from Massachusetts southward, but in Vermont it occurs only sparingly in the southeastern and southwestern counties. It will, however, grow if introduced farther north and deserves to be so planted much more commonly than has yet been done. It is a clean, shapely bush or small tree, and the profusion of its snowy white flower clusters in late spring and of scarlet fruit in the fall makes it a conspicuous and charming feature of the landscape. So safe a harbinger of spring is it, that the Indians taught the early settlers to plant their corn when the dogwood blossomed. Many interesting uses have been made of the flowering dogwood other than for ornament. Its bark supplies an excellent tonic, said almost to rival quinine. Indeed the early botanical explorer, Peter Kalm, says that the colonists had such faith in the virtues of dogwood that "when the cause fell down in spring for want of strength the people tie a branch of this tree to their necks thinking it will help them." When powdered it has been used as a dentifrice, and a bunch of the smaller twigs has been found by the Virginian negroes an efficient tooth brush. The bark steeped with iron sulphate makes a good black ink, and from the bark of the smaller roots a scarlet dye was made by the Indians. The wood is very hard, of fine texture and prized for turning and for tool handles.



BUNCHBERRY.
Flowering plant, × ½.

BUNCHBERRY. *Cornus canadensis* L.

This is often also called the dwarf cornel since it is the only one of so dwarf a size. Indeed it scarcely seems proper to call this a woody plant at all, inasmuch as only the slender creeping stem below ground is woody. It is a familiar plant in cool, moist woodlands from the lowest altitudes to the mountain summits. Its charm begins with the opening of the flower clusters in May, or on the higher mountain slopes in June, and increases with the maturing of the compact bunches of scarlet fruit. The bright berries are a favorite with children, by whom they are sometimes eaten, being palatable with a slightly sweetish taste though rather insipid and seedy. They are also sometimes made into puddings.



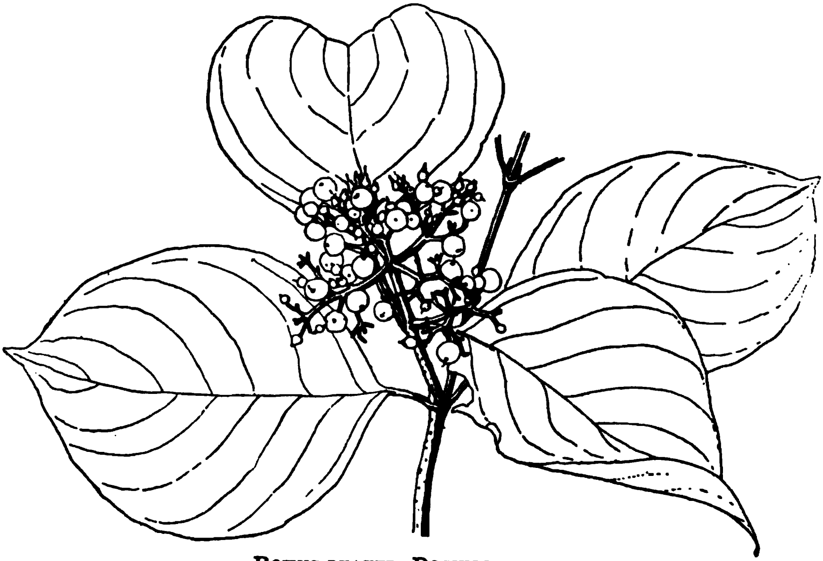
ALTERNATE-LEAVED DOGWOOD.
Fruiting branch, × ½.

ALTERNATE-LEAVED DOGWOOD. *Cornus alternifolia L.f.*

This is frequent in moist, wayside thickets and open woodlands. It forms a beautiful shrub of five to fifteen feet, or even a small tree when in the open, the lateral branches tending to form successive horizontal stages. The broad, flat clusters of small, white flowers, followed by the blue-black fruit about one-third of an inch in diameter, serve to show that it is a dogwood. The leaf arrangement differs from those of any other species in that the leaves are alternate, forming close clusters near the end of the branch. The form and size of the leaves is shown in the figure. They are nearly smooth above and whitish and minutely hairy below. The branches are usually greenish streaked with white. The beautiful browns of the young shoots and the similar tints returning in autumn add to the charms which combine to make it one of the most attractive of the native shrubs for ornamental planting.

ROUND-LEAVED DOGWOOD. *Cornus circinata* L'Her.

This is a shrub of four to eight feet, common along waysides and in woodlands. The small white flowers are borne in rather dense flat clusters, two to three inches across. The fruit is a pale blue, or it may turn to a whitish color, many of the berries



ROUND-LEAVED DOGWOOD.
Leaf and fruit, × ½.

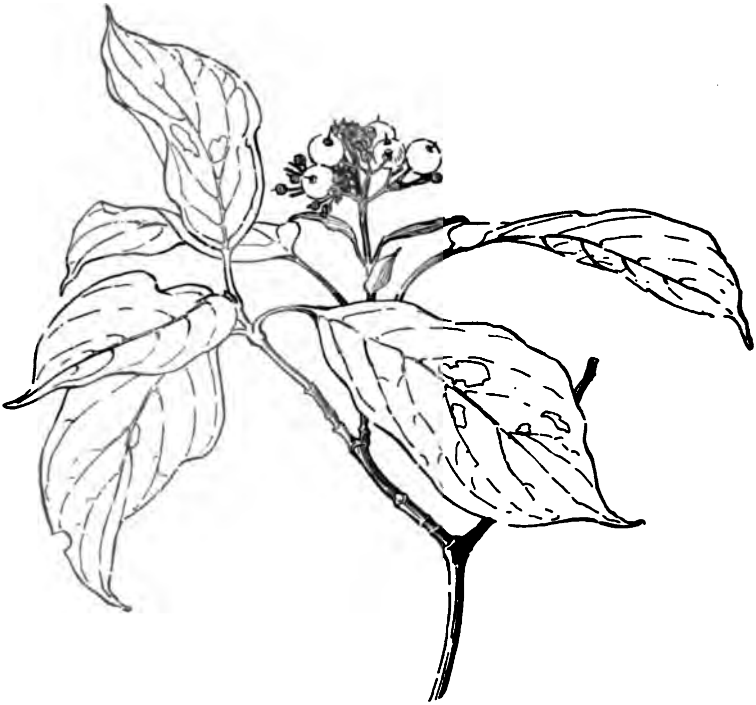
being abortive. The branches are greenish, profusely blotched with purple and usually warty-dotted. The leaves are opposite, broadly ovate and often nearly round, or sometimes even wider than long, abruptly pointed, slightly downy above and pale and densely soft-woolly below. It is a clean attractive shrub whether ornamenting wayside thickets or for landscape planting. The bark, like that of the preceding species, has sometimes been used in medicine as a tonic.

SILKY DOGWOOD. *Cornus amomum* Miller (*C. sericea* L.)

This is also known as swamp dogwood in recognition of its preference for a moist habitat, bordering damp woods and keeping the button bush company along the streams. It occurs also on higher ground. It is a branching shrub with stems somewhat purplish, rising three to ten feet. Its name comes from the silky down which typically clothes the young twigs and lower leaf surfaces. The berries, when mature, are about one-fourth inch in diameter and of a pale blue hue. The bark has sometimes been used in medicine as a tonic in the same way as has that of the two preceding species. The Indians so employed it. They also made a black dye from the bark and a scarlet one from the rootlets. Kinnikinnik is the aboriginal name for a favorite smoking mixture of the Indians, consisting of tobacco and the scrapings of the wood of the silky dogwood, a name which has been given a permanent place in geography as the name of a Wisconsin town.

RED-OSIER DOGWOOD. *Cornus stolonifera* Michx.

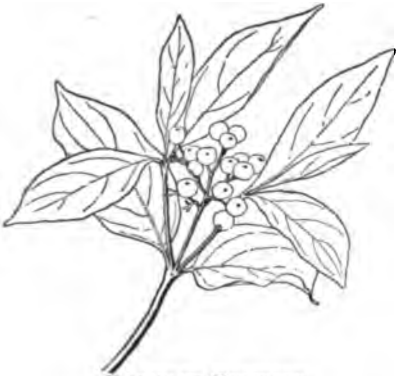
The red-osier dogwood is a spreading shrub from four to eight feet high, usually with the lower parts of the stem prostrate and soon rooting to form clumps of indefinite expanse. This creeping habit of the stems gave it its Latin name. The slender osier-like appearance and the characteristic reddish color gave rise to the English name. The flower clusters are white, usually relatively small; the berries, one-fourth inch in diameter, ripening to white or lead color. A taste thereof will prove their unpalatability, yet it is said that the western Indians rated them among their foods. A French chemist has shown that the fruit yields one-third its weight of an oil similar to olive oil. The chief interest attaching to this plant, however, is because of the increasing use made of it for ornamental purposes. Both in nature and for landscape planting it is highly attractive whether in summer or winter and its spreading habit adds much to its value for certain situations.



RED-OSIER DOGWOOD.
Fruiting branch, × ½.

PANICLED DOGWOOD. *Cornus paniculata* L'Her.

This is a slender, much-branched, erect plant, four to eight feet high, commonly bordering highways and riverbank thickets. The smooth gray branches, rather narrow leaves whitish beneath, numerous close clusters of white flowers and white fruit borne on a pale scarlet stalk, serve to make it comparatively easy of distinction. It adds an attractive feature to the natural landscape and is excellent for ornamental planting, but no other use has been made of it.



PANICLED DOGWOOD.
Branch with fruit, × ½.

HEATH FAMILY. ERICACEAE

This includes the largest group of Vermont shrubs except the rose family. Like that it has many valuable species, whether for fruit or ornament, and some quite puzzling to one who attempts to know all the shrubs at sight. To facilitate the solution of such puzzles the following key to the shrubby genera has been prepared and under each genus there is, in addition, a key to the species.

Some of the other heaths not here included are slightly woody, notably the prince's pine (*Chimaphila*) which is a pretty evergreen, about six inches high, common in sandy woodlands, and the shin leaves (*Pyrola*). There are several species of the latter closely resembling each other in general characters. Some of them have leaves so similar to the arbutus as to confuse the mayflower hunter, while others look more like the wintergreen. Very similar to the heath and closely related thereunto is the little diapensia, whose dainty dark green cushions dotted with large white blossoms is reward enough for any flower lover who may venture to visit the alpine peak of Mt. Mansfield during the last of May.

KEY TO THE GENERA OF SHRUBBY HEATHS.

1. Fruit a berry or berry-like ....2.
1. Fruit a dry capsule ....5.
2. Calyx below the ovary, leaves evergreen ....Bearberry
2. Calyx borne upon or inclosing the ovary and appearing as teeth crowning the edible berry ....3.
3. Berries white; leaves evergreen ....Snowberry.
3. Berries blue or black; leaves deciduous. Blueberries and huckleberries.
3. Berries red; leaves evergreen ....4.
4. Berries tart, 4-celled, crowned by 4 small calyx teeth, leaves less than ½ inch long ....Cranberries
4. Berries spicy-aromatic, 5-celled and surrounded by 5 conspicuous calyx lobes, leaves 1 inch or more in length....Wintergreen.
5. Flowers small, less than ¼ inch wide, petals united into an urn-shaped or cylindrical tube with contracted mouth..........6.
5. Flower larger, ⅝ to 2 inches wide, open and spreading above....8.
6. Flowers ½ inch in diameter nearly globular........Male berry.
6. Flowers larger and more elongated ....7.
7. Leaves white beneath with margins rolled back....Wild rosemary.
7. Leaves scurfy both sides, not white beneath, flat....Leather leaf.
8. Flowers without tube and much broader than long (saucer or wheel-shaped) ....9.
8. Flowers tubular or contracted below, spreading above, (salver, funnel or bell-shaped) ....10.
9. Petals nearly or quite distinct, leaves coated underneath with woolly hairs ....Labrador tea.
9. Petals united, leaves smooth ....Laurels.
10. Small trailing plant ....Trailing arbutus.
10. Erect shrubs ....The rhododendrons.

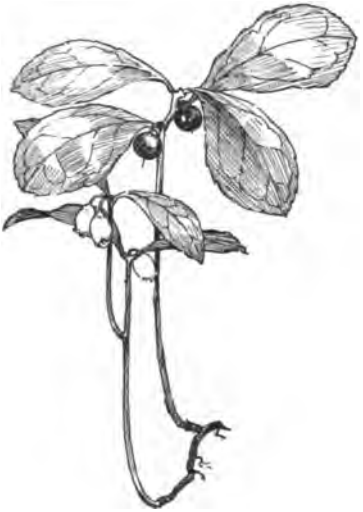
BEARBERRY. *Arctostaphylos uva-ursi* (L.) Spreng.

The bearberry is a trailing plant forming close mats on dry, barren or rocky soil. The woody stems, one to two feet long, are slender but rise from a strong central root. The leaves are small, thick, smooth, shining and evergreen. The flowers are small, drooping and white or rose color. The fruit ripens in late summer to a red color and is about the size of a pea. It is abundant and, since it persists through the winter with the glossy evergreen leaves, it is a conspicuous and well-marked shrub. The bearberry is common in the north of Europe, and the leaves have there been used from ancient times as a diuretic and astringent tonic. Their abundant tannin content has caused them to be collected in large quantities in Russia, Scandinavia and Iceland for use in tanning the finer leathers. They are also used for brown and black dyes. The North American Indians mixed the leaves with their smoking tobacco, as they did the silky dogwood, under the name of Kinnikinnik. The berries are dry, mealy and insipid, but are eaten by partridges and other birds in winter. The bearberry is a handsome ornamental shrub for planting in dry rocky situations.

RED BEARBERRY, × ⅜.

WINTERGREEN. *Gaultheria procumbens* L.

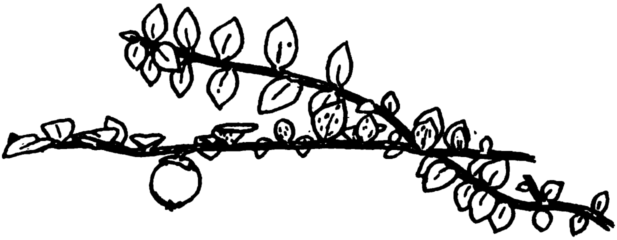
The creeping wintergreen is a common plant in cool damp woods, especially in sandy soil. It is familiar to every child where it occurs, and is so easily distinguished by the characteristic spicy, aromatic "wintergreen flavor" of berries and leaves, especially the younger ones, that no description is necessary to insure its recognition. It goes under various other common names, of which checkerberry is the one most used in Vermont. "Checkerberry Corners" was formerly the name of a small post-office in Chittenden county, but the post-office department recently changed it to something considered more dignified, whether or not it was appropriate. It is sometimes termed partridge or grouse-berry, in recognition of its food value to partridges and to other hibernating birds, but this name properly belongs to a still daintier creeping vine. The deer are also said to relish the fruit in autumn. It is always a pleasing plant to meet whether it is in late fall or early spring that one comes upon a bed of the polished, leathery, evergreen leaves and tempting red berries, sometimes two or three on a stem; or a little later, when the tender, spicy, bronzed young sprigs are in evidence; or yet again in midsummer, when its dainty, drooping white flowers are half hidden under the foliage. These attractions combine to make it desirable for ornamental planting in borders and rockeries. The leaves were sometimes used as a substitute for tea during the Revolution; whence the name sometimes used, "mountain tea." Wintergreen oil is an agreeable aromatic product much used in flavoring confections and possessing mild medicinal properties. Ten pounds may be distilled from a ton of leaves. Much of the so-called wintergreen extract of the market is, however, obtained from the sweet birch.



WINTERGREEN.
Flowers and fruit, × ½.

CREEPING SNOWBERRY. *Chiogenes hispidula* (L.) T. & G. (*C. serpyllifolia* Salisb.)

This dainty little creeping plant is an evergreen, frequent in cool bogs and moist mossy woods. It is only slightly woody and so its place is doubtful in the present list. Its relationship to the wintergreen is evidenced by the like flavor of its leaf. Its distinguishing characters are the very small leaves with margins rolled back, having rusty hairs below and also on the branches; its small nodding white flowers; and its snow-white, sweet, edible berries as large as small peas, ripening in late summer and autumn.



CREEPING SNOWBERRY.
Fruiting branch, natural size.

HUCKLEBERRY. *Gaylussacia baccata* (Wang.) Koch.

This shrub is familiar to all who have "gone blueberrying" in late July and August. It is a frequent plant on rocky hillsides and thickets, but thrives best in sandy or peat soil and so is often found in bogs. The leaves are easily distinguishable from the blueberries or other similar shrubs by their yellowish green tint above and the tiny resinous globules exuded from the lower surfaces. These give the underside of the young leaves a slightly rough, sticky feel and a glistening appearance if held in the sunlight. Later they may dry to a slight rusty scurf. The berries are sweet and of a peculiar flavor, preferred by many to that of the blueberries in spite of the fact that their seediness makes them objectionable. This seedy character, so evident between the teeth, probably accounts for its occasional name, crackleberry. Another, and in some sections, commoner name is whortleberry, said to come from the old Saxon heort-berg or hart's berry, from which our hurtleberry and huckleberry are in turn a corruption. How much interesting history may be wrapped up in a homely name! The fruit of the huckleberry is one of the regular market berries of late summer. It shows numerous varieties varying to blue (blue huckleberry) with a heavy bloom and with leaves either green on both sides or with a bluish bloom. Various shades of scarlet and crimson develop in the autumn foliage of this plant and add an aesthetic charm to its commerciel value.

HUCKLEBERRY.
Fruiting branch, × ½.

THE BLUEBERRIES.

There are some eight kinds of blueberry found in Vermont. Three of these, however, are rare, being practically confined to the alpine summits of the higher mountains; but the other five furnish fruit to the berry picker in one or another section of the state. It will suffice the purpose of any except the mountain climbing botanist to distinguish these five as listed in the key below. While none of these are cultivated for their fruit, large quantities of blueberries are gathered from the wild native plants. Attempts to cultivate blueberries have led to encouraging results in a few cases, the best returns being obtained with the common high-bush form[1].

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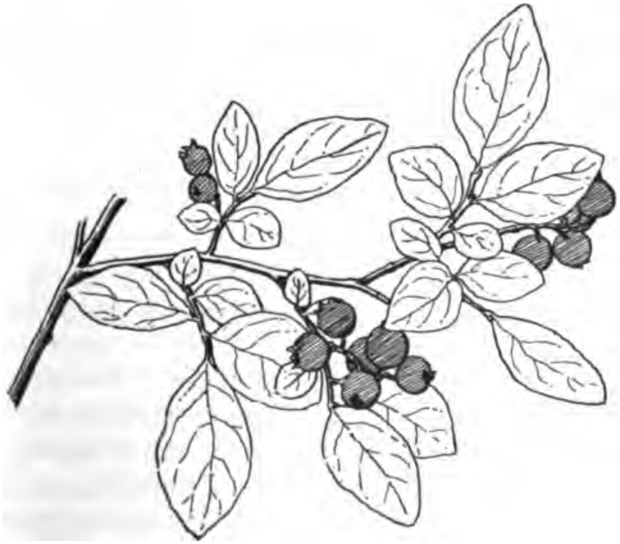
[1] Anyone contemplating engaging in this industry should acquaint himself with the publications of Prof. W. M. Munson. See especially Me. Sta. Bul. 76 (1901).

THE COMMONER BLUEBERRIES.

1. High-bush forms, generally over 4 feet ....2.
1. Low-bush forms, generally less than 3 feet ....3.
2. Berries bluish-black with much bloom.
Common high-bush blueberry.
2. Berries dead black without bloom......Black high-bush blueberry.
3. Branchlets and leaves downy.....................Canada blueberry.
3. Branchlets and leaves smooth or nearly so ....4.
4. Leaves green and shining on both sides, distinctly but minutely toothed ....Early low blueberry.
4. Leaves pale or glaucous below, margins entire or sparingly toothed ....Late low blueberry.

COMMON HIGH-BUSH BLUEBERRY. *Vaccinium corymbosum* L.

This is the common tall or swamp blueberry frequenting the low wet thickets over much of the state, and furnishing the abundant late blueberry in the swamps about northern Lake Champlain. It is a tall straggling shrub, typically five to ten feet or even taller, but it varies quite widely in this and all other characters. The branches are greenish brown with minute



HIGHBUSH BLUEBERRY, × ⅔.

brownish roughenings. Its leaf shape is shown in the drawing. It is typically about two inches long but may vary from one to three inches in length, entire and without hairs, the surface being green and smooth above, paler and often hairy below. A more pubescent form, green on both sides, occurs in some cold bogs (var. *amoenum*). The fruit is large, dark blue with bloom, ripens chiefly in late August. Its larger size and fine flavor make it the favorite market berry where obtainable. As already suggested it is easily transplanted, grows rapidly in any good soil and appears responsive to culture. It can be grafted if desired and doubtless, with improved varieties and cultural methods better understood, it will be added to our garden fruits.

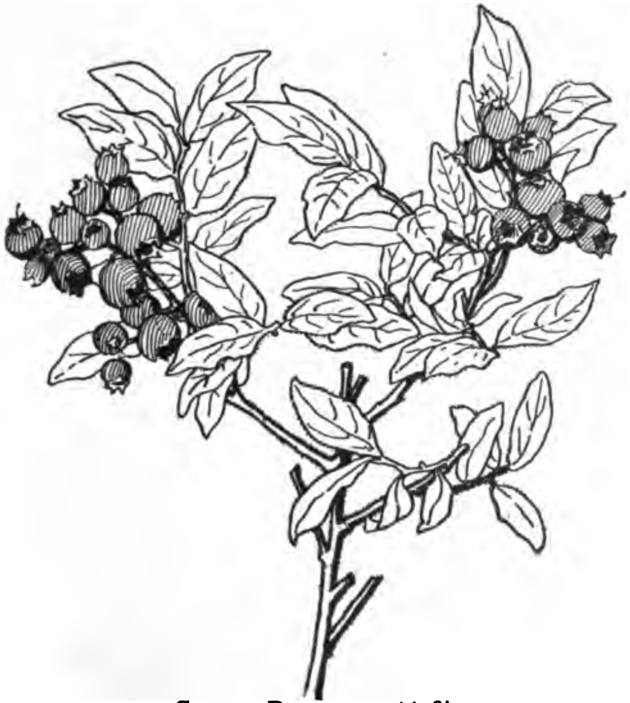
BLACK BLUEBERRY. *Vaccinium atrococcum* (Gray) Heller.

This form is much like the high bush variety in most respects except that the fruit is smaller, black and without bloom. The leaves are downy or wooly underneath even when old, as are also the branchlets. It has been found in a few bogs but apparently is not common.

CANADA BLUEBERRY. *Vaccinium canadense* Kalm.

This is a low shrub one to two feet high, erect, densely branched, with young twigs yellowish-green and downy, older branches brownish. The leaf-form is shown in the figure. The best character whereby one may be able to identify this species is to be found in the downiness of its leaves and twigs. Because of this peculiarity the name velvet-leaf is often given to this blueberry. The berries are blue with much bloom and ripen rather late along with the common high-bush blueberry. It is frequent in the more elevated parts of Vermont, preferring moist thickets or rocky places, and is not found in swamps. It is said to be the commonest market berry of Essex county. The berries are of good flavor but more acid than are the common low-bush blueberry; hence the local name "sour-top" is sometimes heard.

They are also slightly smaller than are either the common low-bush or high-bush berries, but they are quite prolific. Their smaller size and relative sourness make them less popular as market berries than are the others.



CANADA BLUEBERRY, × ⅜.

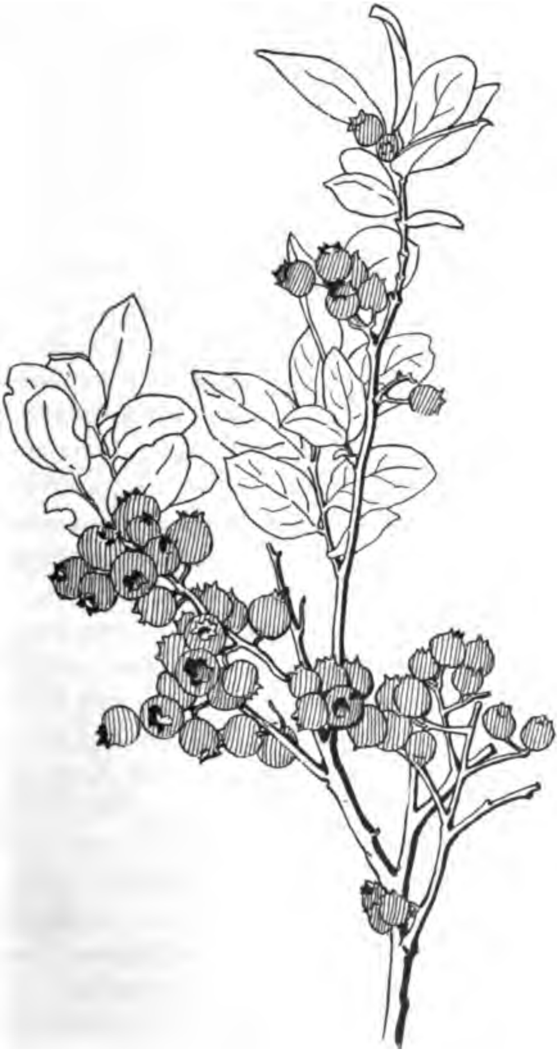
EARLY LOW BLUEBERRY. *Vaccinium pennsylvanicum* Lam.

This is a low or dwarf shrub of one to two feet in height. The slender branches are greenish, warty and generally smooth. The leaves are thin, small and narrow as shown in the figure and grade into the still smaller mountain variety (variety ***angustifolium***) mentioned later. The fruit is typically bluish-black with bloom, but a form sometimes occurs having berries without bloom, (***nigrum***). It is the commonest berry on the low sandy plains and pine barrens and is frequent elsewhere in dry sandy or rocky hillsides and open woodlands. The characters given in the key serve to distinguish it from the next named form, but the important thing from the berry-pickers' standpoint is that this is the earliest blueberry we have, ripening in late June and July. It is extremely prolific and the berries are large, very sweet and of fine flavor, making it the favorite early market berry. Indeed it supplies the bulk of the blueberries in all eastern markets. Although common in Vermont it is still more plentiful in adjacent sections of northern New York and Canada, so that large quantities of berries from these points are shipped into Vermont and to other and larger markets. When mowed the new shoots produce the following year long spike-like masses of bloom and fruit which may be stripped off by the handful. This species stands next to the high-bush berry in possibilities of cultivation and improvement.

EARLY LOW BLUEBERRY. × ⅝.

LATE LOW BLUEBERRY. *Vaccinium vacillans* Kalm.

This is a low erect shrub, usually one to two feet but sometimes four feet high, common in dry sandy or rocky soils. Its branches are pale, yellowish green, warty, free from hairs; its



LATE LOW BLUEBERRY, × ⅜.

leaves are distinguishable from those of the early low form, as shown in the key and the accompanying cut, by being larger and broader, smooth with entire margins, pale green above and whiter underneath. The fruit is a large blue berry with much bloom and excellent flavor. It ripens in July and August along with the late high berries and so contributes a part of the later market berries. It deserves the attention of anyone attempting blueberry culture, though it is not so promising as the two previously commended.

THE MOUNTAIN BLUEBERRIES.

Anyone visiting the higher mountain summits, especially Mansfield, in midsummer may find the following three mountain blueberries. All are dwarfs, but a few inches in height, matted in the moss of boggy depressions along with the bearberry and mountain cranberry. The fruits of all are sweet and edible.

The narrow-leaved variety of the early dwarf blueberry already described (*V. pennsylvanicum* var. *angustifolium* Gray) is found on Mansfield and Camel's Hump, only a few inches in height and with narrower and lanceolate, minutely-toothed leaves, and berries bluish-black with bloom.

The bog bilberry, (*V. uliginosum* L.) forms low tufts with the preceding and has been found at lower altitudes. It is characterized by the shorter rounded leaves with an entire margin, which show a dull bluish cast above, and are paler and slightly pubescent beneath. The fruit is blue-black with bloom.

The dwarf bilberry (*V. caespitosum* Michx) completes the arctic trio. Its leaves are larger than those of either of the others, minutely toothed, yellow green, smooth and shining on both sides. Its berries are larger and blue with bloom. This is at home on "the chin," the highest point of Mount Mansfield, but has also been located in Newfane and Washington.

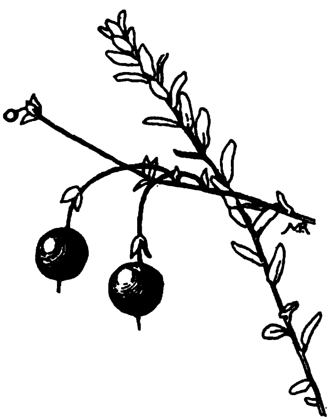
THE CRANBERRIES.

It may surprise some to learn that there are at least three kinds of cranberry native to Vermont. Since all are edible, and one of them is the same as the species so profitably cultivated in Massachusetts and New Jersey, it leads one to question why more has not been done with cranberry growing in Vermont. There is no reason apparent why cranberry bogs might not be successfully established at many places in the state. Indeed this has been done by several parties in years past. The native cranberries all have low creeping stems, small evergreen leaves and red berries. The species are distinguished as follows:

1. Underside of leaves green and dotted with blackish, bristly points ....Mountain cranberry.
1. Underside of leaves whitened and smooth ....2.
2. Leaves acute-pointed, margins rolled strongly backward (revolute) ....Small cranberry.
2. Leaves obtuse pointed, margins less revolute......Large cranberry.

LARGE CRANBERRY. *Vaccinium macrocarpon* Ait.

The large or American cranberry is cultivated in Massachusetts, especially at Cape Cod, in New Jersey and Wisconsin. The cut shows leaf and fruit relations well. The berries are usually spherical or somewhat elongated, red when ripe, one-half inch more or less in diameter, and of characteristic acid flavor. The fruit even in the wild state varies considerably in color and outline, and under culture several such varieties have been developed and named. It is peculiarly an American fruit but has already found a large market abroad. The plant is frequent as a native in peat bogs, open swamps, or wet shores at



LARGE CRANBERRY, × ½.

the lower altitudes. It seems to prefer grassy swamps or sandy bogs. The stems are slender, prostrate, one to four feet long, rooting at the joints and throwing up erect branches a few inches in height upon which the flowers and fruits are borne. It is stated on good authority that cranberry culture will nearly always prove successful on bogs where the berry is native, providing certain conditions can be complied with. Chief among these are:

1. A level surface capable of drainage;
2. Abundance of clean sand;
3. An ample supply of water which can at need be held in storage. The flooding of the bog at will is necessary for winter protection, spring retardation, and possible use in summer and autumn against injurious pests or early frost.

SMALL CRANBERRY. *Vaccinium oxycoccus* L.

The stem of this species is shorter and more slender than that of the larger one just described, but its habit of growth is in other respects quite similar. The difference in leaf character is made clear by the key on the preceding page. The fruit is only about one half the diameter of the larger species, reddish and often speckled with white when young. The flavor is similar to that of the large berry and is preferred by some. It is a sub-arctic plant often found in Vermont in cold peat bogs. It is collected and used, when in sufficient quantity, and is even offered occasionally in the Vermont markets. This is the cranberry of the old world, large quantities being supplied from Russia to the south of Europe. A variety of this species (var. *intermedium* Gray) occurs occasionally which is intermediate in leaf and fruit characters between this and the large cranberry.

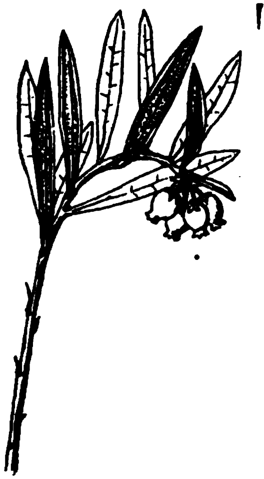
MOUNTAIN CRANBERRY. *Vaccinium vitis-idaea* L. var. *minus* Lodd.

This species is also known as the cowberry and foxberry. It is a mountain species found in Vermont only on the summits of

Mansfield and Camel's Hump. There it is abundant enough so that the berries are often gathered for sauce by summer visitors. They are about the size of the small cranberry, dark red, and rather bitter when uncooked. It is abundant in sections of Canada where it is used in the homes and offered in some markets. The habit of the vine is similar to that of the other cranberries, but its branches are shorter and its leaves larger, leathery, and of a glossy, dark green. It is recommended for planting in ornamental borders.

WILD ROSEMARY. *Andromeda glaucophylla* Link. (*A. polifolia* L.)

The wild rosemary or water andromeda is a bush one to three feet high, frequently found in wet, peaty soil, especially bordering bogs and boggy ponds. It has red flower buds which expand into small white or pinkish flowers, nodding in clusters at the ends of the branches, followed by dry globular capsules. The characters most surely recognizable pertain to the leaves, which are narrow—about one-fourth by two inches—with margins strongly recurved, white beneath, evergreen and thick. They are somewhat acrid and contain a narcotic poison which is said to prove fatal to browsing sheep.



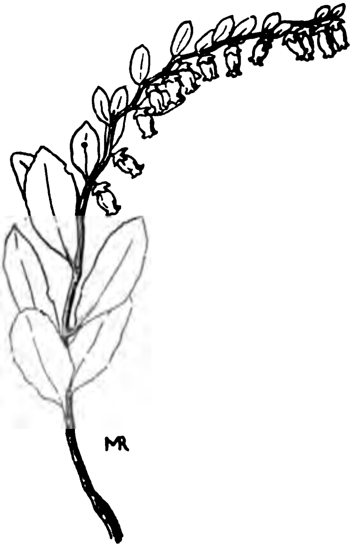
WILD ROSEMARY.
In flower, × ⅝.

MALE BERRY. *Lyonia ligustrina* (L) DC. (*Andromeda Xolisma*).

This is occasional in southern Vermont in damp woodlands. It is a deciduous shrub three to ten feet high. The small white blossoms are borne in many-flowered terminal clusters which are often several inches long.

LEATHER LEAF. *Chamaedaphne calyculata* (L.) Moench. (*Cassandra*).

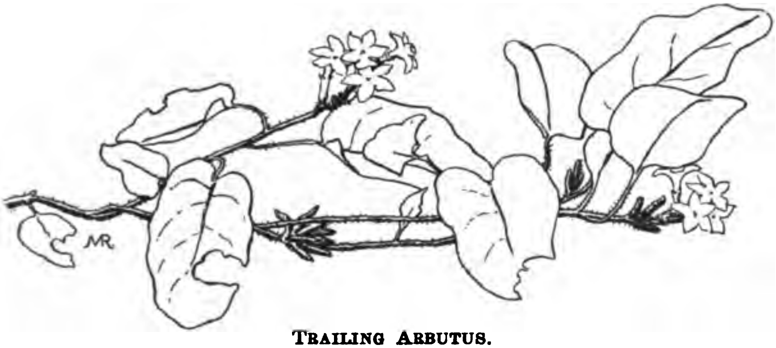
This species is closely allied to the preceding shrubs. It favorite habitat, also, is wet places and it is frequent in boggy meadows and swamp borders. It grows two to four feet high and spreads by suckers which enable it to form large beds. The leaves are evergreen, leathery in texture, covered on both sides, but more densely below, with minute, roundish, scurvy scales. Those of the upper surface are whitish and appear to the naked eye as tiny white specks; on the lower surface they are brown and give this side a rusty appearance. The egg-shaped flowers appear in early spring, hanging like rows of tiny white bells from the undersides of the younger twigs. It is one of the shrubs which make the swamps attractive to the nature lover.



LEATHER-LEAF.
In flower, × ½.

TRAILING ARBUTUS. *Epigaea repens* L.

Everyone knows the arbutus or mayflower. Emerson says of its occurrence in Massachusetts, "Often from beneath the edge of a snowbank are seen rising the fragrant, pearly-white or rose-colored, crowded flowers of this earliest harbinger of spring. It abounds in the edges of the woods about Plymouth, as elsewhere, and must have been the first to salute the storm-beaten crew of the Mayflower on the conclusion of their first terrible winter. Their descendants have thence piously derived the name, although its bloom is often found before the coming of the month of May." The flower buds are formed the preceding summer and so are ready to swell with the first premonitions of spring. The arbutus is common in certain regions, preferring sandy soil; and its growth is sparse wherever such soil conditions are lacking. Those gathering it should realize that its shrubby stems are of relatively slow growth, and that their normal development is conditioned on their lying as they naturally do, close to the soil. Wherever there is danger of its extermination, therefore, the flower clusters should be cut without disturbing these stems unnecessarily. A notice stating this fact has been prepared by the Society for the Protection of Native Plants. A copy of it may be secured for posting in any school room or other suitable place by addressing the secretary of that society at the Library of the Boston Society of Natural History.



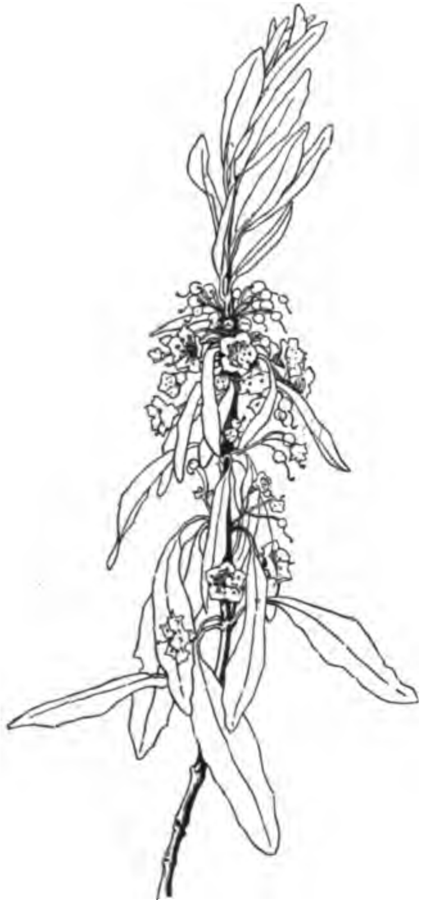
TRAILING ARBUTUS.
In flower, × ½.

THE LAUREL. KALMIA.

The name "laurel" most properly belongs to a European plant as noted under the laurel family on an earlier page. In this country it has been applied rather indiscriminately to several others. The kalmias however by popular usage are denominated as the American laurels, the large rhododendron alone having claims that rival them. And this group of plants, for the kalmias and rhododendrons are closely allied, are well worthy the distinction, so preeminent are they for richness of evergreen foliage as well as for flower. Vermont boasts three species of kalmia. In passing it is worthy of note that Linneaus chose this rather curious name in honor of his pupil, Peter Kalm, who was sent to America as a botanical explorer by the Royal Academy of Sweden in 1748. He spent some weeks in the Champlain valley, carrying many plants back to Europe for study and naming. He was doubtless the first botanist to visit Vermont. Among other things he recorded the fact that the young sheep of the early colonists browsing in winter upon the evergreen leaves of the laurel were fatally poisoned and that other stock were made very sick. Kalm's observations were made especially on the mountain laurel. Later records showed the sheep laurel to be similarly poisonous. It has also been shown that honey made from these two plants is poisonous, and it is claimed by some that when partridges feed on the buds their flesh is rendered unwholesome. The flowers of all the kalmias are curious and interesting. They are saucer-shaped with their stamens bent backward and anthers concealed until maturity in pockets in the corolla. When the blossom is fully open and these are touched by a visiting insect they are released and with a spring-like action dust pollen over the visitor's body, thus insuring cross-pollination. Someone has compared them in form to miniature parasols, the corolla to the cover, the reflexed stamens to the ribs, and the central style to the handle. The illustrations, especially of the mountain laurel, will help to make these points clearer, but they need to be seen in a fresh blossom if one is fully to appreciate their beauty.

1. Leaves bright green both sides, relatively broad, i. e. one inch or more wide by two to three long........Mountain laurel.
1. Leaves paler or whitish underneath, relatively narrow, i. e. one-half inch or less wide ....2.
2. Leaves with margins rolled strongly backward, white underneath, flower clusters at end of branch..........Pale laurel.
2. Leaves not so rolled or white underneath, flower clusters along side of branch with young leafy shoots at end..Sheep laurel.

SHEEP LAUREL. *Kalmia angustifolia* L.



SHEEP LAUREL.
In flower, × ½.

The sheep laurel is the commonest of the three species, being an erect shrub one to three feet high, forming patches on hillsides and in low moist sandy soil. It is rather unattractive with its somewhat drooping foliage until the bright purplish flowers appear. Even then it is Cinderella of the trio. Its reputation as a poison to sheep is witnessed in its common names, sheep laurel and lambkill, and it is held by some to be even more poisonous to stock than is the broad-leaved laurel.

PALE LAUREL. *Kalmia polifolia* Wang. (*K. glauca* Ait.)

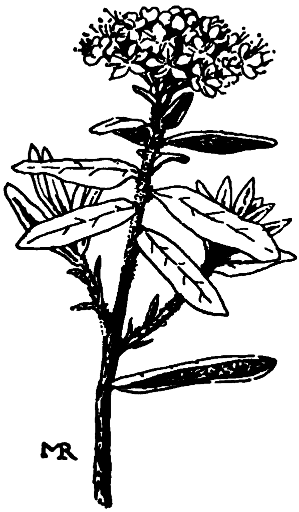
This is a small straggling shrub about one foot high which occurs occasionally in cold peat bogs. It is well characterized by the leaves, dark green above, whitish beneath, with margins rolled back. The twigs also are peculiar in being two-edged. The flowers are showy, lilac-purple, one-half inch in diameter. They form showy clusters making the plant conspicuous and attractive when in flower about the first of June.

MOUNTAIN LAUREL. *Kalmia latifolia* L.

This most beautiful shrub is the laurel of southern New England, but in Vermont, unfortunately, it occurs native only in southern valleys. It is known by a variety of popular names; broad-leaved laurel, to contrast it with the other two; calico-bush, from its showy rose and white blossoms; spoonwood, from the use of its wood by the Indians for carving into spoons. Clamoun was the Indian name. The poisonous nature of this plant has already been discussed; fortunately, however, where its character is understood this is easily guarded against, hence there is no necessity to wage war on this beautiful plant. On the other hand, since it is easily transplanted, it deserves to be used far more than it is as an ornamental shrub.

LABRADOR TEA. *Ledum groenlandicum* Oed.

This is a straggling, branching shrub of one to four feet in height. It is of frequent occurrence in Vermont in cold peaty bogs and wet mountain woods, preferring sandy soil. It is typically a northern plant as witnessed by its name. It has most curious leaves, thick and leathery with margins rolled strongly backward, dark green above and densely covered below with woolly hair which may be white on the youngest shoots but is rusty brown on the mature leaves. Since these hairs are nature's device to check the loss of water, it seems strange that a bog plant



LABRADOR TEA.
Flowering branch, × ⅜.

should be provided with them. The flowers are white about one-third of an inch across, forming a rather showy cluster at the end of the branch in early summer. The leaves are rich in tannin and possess some narcotic principle. They are used for tanning in Russia. In Labrador a decoction of the leaves is sometimes drunk as a tea, whence the name. It is said, though we cannot vouch for the authority, that it was also so used in the American colonies during the Revolution.

AZALEA. RHODODENDRON.

These names suggest our most showy flowering shrubs. There are three species in Vermont, all worth looking for but none common. The flowers of the rhododendrons are very showy, slightly irregular and with the curved stamens extruded. All the native rhododendrons are worthy of culture. This offers no difficulty providing that they are planted in moist peaty soil such as abounds naturally or is easily prepared.

1. Leaves evergreen and large (two by five inches or more). Great rhododendron.

1. Leaves deciduous and smaller (one by two inches or less).......2

2. Leaves about one-half as wide as long, petals united for one-half their length into a tube; stamens usually 5. Pink azalea.

2. Leaves about one-third as wide as long, petals almost distinct; stamens 10 ....Rhodora.

GREAT RHODODENDRON. *Rhododendron maximum* L.

This is known to occur in only a few places in northeastern Vermont, about the shores of Groton and neighboring ponds. It is there a low spreading plant of three to six feet with the lower branches semi-prostrate. The fully developed leaves are from four to six inches or more in length and one-fourth as wide. They are thick, smooth and leathery, on thick leaf-stalks, evergreen and persistent or several year. The flowers open about July 1. They form in large clusters at the ends of the shoots, are about one and one-half inches across and of somewhat variable pale-rose tints sprinkled with yellowish or reddish dots. It is the most showy of our native flowering shrubs and is one of the most beautiful of all native flowers. It is often cultivated as an ornamental plant, but the stock in these cases is usually obtained through nurserymen from the Alleghany mountains, where it is much more abundant. It deserves much wider use than has been made of it as yet in Vermont.

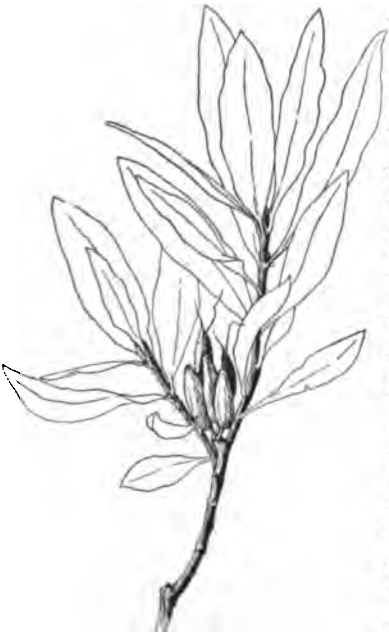
PINK AZALEA. *Rhododendron canescens* (Mx.) G. Don.

This shrub is more widely distributed in Vermont than is the rhododendron proper, but it is found only occasionally growing in moist, woody banks and along the borders of swamps. It is sometimes called swamp-pink, June pink, honeysuckle, or pinxter-flower, the first of these names being commonest in local usage in Vermont. The name "may-apple" is sometimes given it because of the large apple-like galls which are common on the twigs. It is a low spreading shrub rarely more than a few feet in height, with oval, deciduous and more or less hairy leaves. The flowers opening the last of May are pink of varying shades, spreading to an inch and a half or more in width and are decidedly cinnamon scented. They have not the delicacy

PINK AZALEA, × ½.

of color of the flowers of the true rhododendron, but the plant excels it in grace and merits more attention than has yet been given it for ornamental planting.

RHODORA. *Rhododendron canadense* (L.) B S. P. (*R. rhodora* L.)
This also is a swamp-loving plant found occasionally in low thickets and bordering cool bogs. It is an upright branching shrub rarely rising above two or three feet in height. The flowers are borne in showy terminal tufts, usually appearing the latter part of May and just preceding the leaves. They are smaller than the other rhododendrons, scarcely an inch long and of a purplish rose color. The leaves are about one-half inch or less in width by one to two inches in length, dark green and smooth above, paler beneath and with minute, rusty hairs. While not as desirable an ornamental as the others of its class, rhodora is worthy a place in the garden of any one fond of hardy, native, ornamental shrubs.



RHODORA.
Branch with fruit capsules, × ½.

OLIVE FAMILY. OLEACEAE

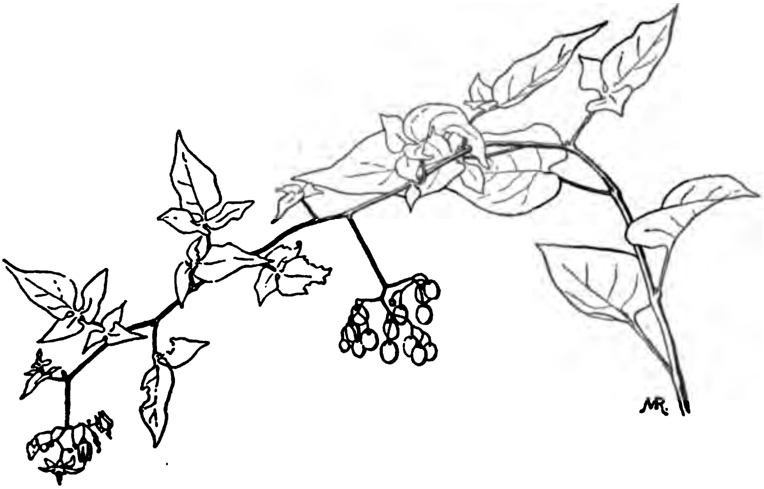
The ash is our only native representative of this family of trees and shrubs. Since all of the ashes are trees they were discussed in "Trees of Vermont." Several of the shrubby species are introduced in cultivation, including the privets (*Ligustrum*), the fringe-tree (*Chionanthus*), and forsythia with its golden bells in earliest spring. More common almost than the ashes are the lilacs, and these are indeed so frequent and persistent as to deserve a place in any list of Vermont shrubs. The common purple and white varieties belong to one European species (*S. vulgaris*). The daintier persian lilac is also frequently seen, and occasionally the less attractive josika lilac, as well as others.

NIGHTSHADE FAMILY. SOLANACEAE

The word nightshade has an unsavory sound to most people. While there are numerous poisonous plants among its members, the deadly nightshade is largely the creation of the poet's fancy. The cultivated tomato and potato are witnesses of the economic worth of some of the group and there are several other members much prized as garden vegetables or ornamental plants. On the other hand the European belladonna and the common wild nightshades of this country, especially the black nightshade, have poisonous properties. Testimony differs, however, as to the toxic effects of the black nightshade. Its berries are sometimes and in some sections eaten with impunity, whereas in other cases serious illness and even death has resulted from their ingestion. It is possible that variations in individual susceptibilities as to their solanin content, or, indeed, differences in such content due to varying conditions of growth, may account for these diverse observations. However, the only safe procedure is to treat the nightshades as poisonous plants and especially to warn children against eating the berries.

CLIMBING NIGHTSHADE. *Solanum dulcamara* L..

This is a common vine in moist thickets, sometimes actually growing in the water, at other times in relatively dry soil, as along fence rows. It is also called bittersweet, but this name is confusing since it is applied to another vine, the celastrus described earlier. It is listed as an introduced plant, but it is now so widely distributed as at least to appear like a native. It is a perennial plant with weak stem, more or less woody at the base but herbaceous above, clambering upon other shrubs or over old fences and stones. The leaves are curiously variable in shape and size. The purplish flowers resemble potato blossoms. The red berries are egg-shaped, about the size of large currants, borne in clusters which become conspicuous and beautiful as they ripen in the autumn. The plant has medicinal properties and was formerly used as an herb remedy in Europe. The name bittersweet probably arose from the fact, as stated by Lindley, that in England the young stems collected in the autumn for medicinal purposes "have at first a bitter taste which is succeeded by an agreeable sweetness." The berries yield green and violet dyes. The climbing nightshade is sufficiently attractive so that it is planted as an ornamental vine to cover low banks and trellises. For most places preferable plants can be found, unless this is introduced for variety's sake.



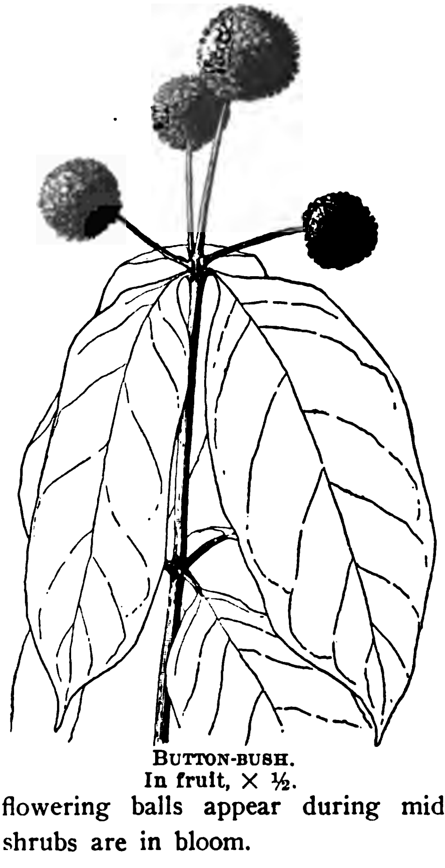
CLIMBING NIGHTSHADE.
Branch with flower and fruit, × ⅛.

MADDER FAMILY. RUBIACEAE

This large family of plants includes several of much economic interest such as madder and other dye plants, the ipecac plant, the cinchonas which are the source of Peruvian bark, and the coffee plant. There are numerous Vermont herbaceous plants including the cleavers and bluet, but only one shrub.

BUTTON-BUSH. *Cephalanthus occidentalis* L.

This is a shrub, usually four to ten feet high, forming thickets commonly in open swamps and along low shores of ponds and streams. It is easily known by the spherical clusters of small white blossoms forming ball-like heads an inch or more in diameter. The greenish heads of fruit which follow the blossoms are also ball-shaped. The large shiny leaves, which add to the plant's attractiveness, are in pairs or threes, and have entire margins and a somewhat leathery texture. The tincture of the bark has been used somewhat as a medicine, but the plant is chiefly to be prized for its ornamental qualities, whether as it occurs in nature or as transplanted. It does quite as well on drier soil and has to recommend it, bright foliage and especially the fact that the curious and attractive flowering balls appear during midsummer when few other shrubs are in bloom.



BUTTON-BUSH.
In fruit, × ½.

HONEYSUCKLE FAMILY. CAPRIFOLIACEAE

This family is to be rated with the cornels, heaths and roses as a source of ornamental shrubs. Nearly all of the Vermont species are shrubs. Some of them furnish dyes and medicines of minor value, but it is chiefly for the beauty of foliage, flower and fruit that they are valued. All are attractive in nature and most of them are used for landscape planting. The family characters are shown in the opposite leaves, rather conspicuous and often irregular flowers, and berry-formed fruit. The six genera are distinguishable as follows:

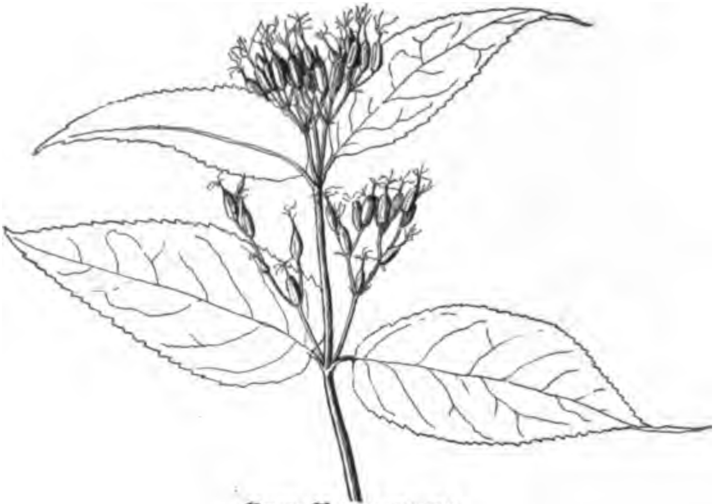
1.	**Flowers in broad, compound clusters**	**5.**
1.	**Flowers solitary in pairs, or in narrow clusters**	**2.**
2.	**A creeping vine**	**Twinflower.**
2.	**Upright or climbing shrub**	**3.**
3.	**Fruit a dry capsule**	**Bush honeysuckle.**
3.	**Fruit a fleshy berry**	**4.**
4.	**Berry white, only 2-seeded**	**Snowberry.**
4.	**Berries colored, several seeded**	**Loniceras.**
5.	**Leaves compound**	**Elders.**
5.	**Leaves simple**	**Virburnums.**

TWIN-FLOWER. *Linnaea borealis* L. var. *americana* (Forbes) Rehder.

This daintiest of trailing plants occurs occasionally in moist, mossy woods especially under evergreens. It is found in northern Europe as well as America and was named for the great Swedish botanist, Linnaeus, with whom it was an especial favorite. It has a slender, woody stem which may creep for several feet beneath the surface of the moss and humus. From this, short stems arise which bear the small round leaves in pairs and, near the summit, slender flower stalks two or three inches high, forking at the top to support the two delicate fragrant, nodding, rose-tinted flowers.

BUSH-HONEYSUCKLE. *Diervilla lonicera* Mill. (*D. trifida* Moench)

This is a modest little shrub, two to three feet high, spreading from the root so as to form groups, bordering woodlands and roadside thickets. The leaves are opposite, rather sharply toothed and with a long tapering point, four delicate ridges connecting the leaf bases, giving a somewhat four-sided appearance. The flowers which open in June and July are honey-yellow, about three-fourths inch long, in small clusters, most commonly of three, arising from the leaf axils near the ends of the stem. These are closely related to the handsome Japanese shrub weigela, which is much cultivated for ornament. Our little native has but slight claim for such purpose although it is attractive in its wild state.



BUSH HONEYSUCKLE.
Fruiting branch, × ½.

SNOWBERRY. *Symphoricarpos racemosus* Michx.

This is a low spreading shrub, usually less than one foot high, found on the cliffs and headlands of western Vermont. It has small roundish leaves, about one inch long, and bears two or three flowers in a cluster in the uppermost leaf axils from which ripen waxy white berries of the size of peas. The snowberry or waxberry often cultivated as an ornamental plant is a larger variety of the same species, (var. *laevigatus*), not native of Vermont but becoming frequent as an escape from cultivation. It resembles its smaller relative save that it is taller, being from two to six feet in height, and that it bears larger leaves and more numerous flowers and fruits. It is, however, best distinguished by the fact that the native species has leaves which are velvety-hairy beneath, whereas the garden variety is without hairs. Some medicinal worth is attributed to the berries.

SNOWBERRY.
In fruit, × ½.

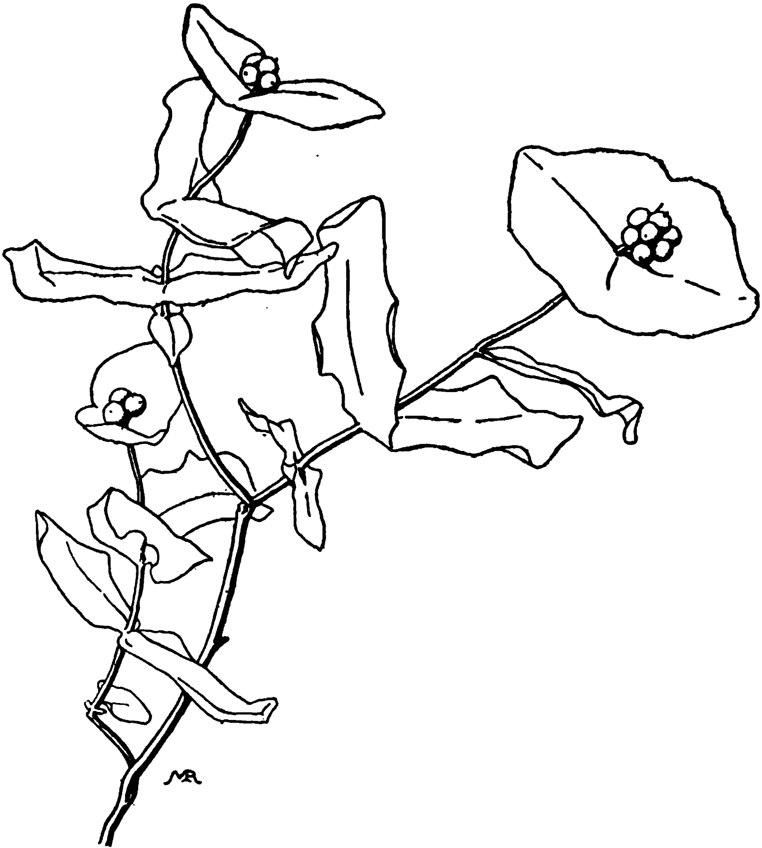
HONEYSUCKLE. LONICERA.

This is a group of six shrubs, five natives and one common in old gardens and as an escape. They are characterized, as explained in the key, by their colored and several-seeded berries. The leaves are in all cases opposite, with entire margins, and the flowers are as a rule rather showy and fragrant.

1. Stems twining, flowers in small terminal clusters, uppermost leaves united at the base ....2.
1. Upright, bushy shrubs with leaves all distinct, flowers in pairs..3.
2. Branches and leaves smooth, whitened (glaucous) beneath. Glaucous honeysuckle.
2. Branches and leaves downy-hairy............Hairy honeysuckle.
3. The flower stem shorter than the flowers, berry double, blue. Blue honeysuckle.
3. The flowers on a distinct stem as long or longer than the flowers; berries reddish or yellow ....4.
4. Tall shrubs (five to fifteen feet) cultivated or escaped. Tartarian honeysuckle.
4. Small shrubs (two to five feet) native ....5.
5. Blossoms in May, berries red, single............Fly honeysuckle.
5. Blossoms in June, berries purplish, more or less doubled. Swamp honeysuckle.

GLAUCOUS HONEYSUCKLE. *Lonicera dioica* L. (*L. glauca* Hill).

This species frequents rocky woodlands preferring dry to moist soils. It has a weakly stem, usually three to six feet long, but capable of developing somewhat of a shrubby habit in the absence of other support. It is a plant of such unusual appearance as to attract attention. The stems are a light gray; the leaves are large, smooth, whitish (glaucous) beneath, the upper ones curiously united in pairs at the base; the greenish yellow or purplish flowers are nearly one-third of an inch long, a half



GLAUCOUS HONEYSUCKLE.
Branch with clusters of berries, × ½.

dozen or so in a compact terminal cluster, followed by a crowded cluster of reddish berries, the size of peas. It is sometimes cultivated as an ornamental plant and deserves attention where a covering is desired for a wall or rock work.

HAIRY HONEYSUCKLE. *Lonicera hirsuta* Eaton.

This occurs only occasionally in the rocky woodlands of western Vermont. It is much like the preceding species in twining habit and general characters. It is, however, a coarser plant with larger leaves, flowers and fruit, and is easily distinguished by the downy-hairiness of the shoots and leaves, especially underneath.

BLUE HONEYSUCKLE. *Lonicera caerulea* L. var. *villosa* (Mx.) T. & G.

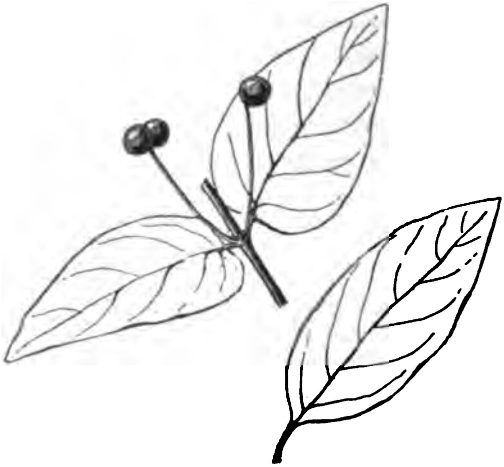
This is a low shrub, one or two feet in height, found occasionally in the cold bogs of northeastern Vermont. It may be readily distinguished from either of the preceding species, but is very similar to the next one. The leaves in both are small with short stems and are rounded at the base. The short flower stem and the double blue berry are, however, characteristic, as explained in the key.

SWAMP HONEYSUCKLE. *Lonicera oblongifolia* (Goldie) Hook.

This is found in a few of the cold, swampy bogs of the state. It is a larger shrub, two to five feet high, similar to the preceding species as well as to the one that follows. It is distinguishable from the blue honeysuckle, as explained in the key, by the longer flower stem and the purplish and more or less united berries, and from the fly honeysuckle by the marked differences in the fruit as indicated in the key on page 179.

FLY HONEYSUCKLE. *Lonicera canadensis* Marsh. (*L. ciliata* Muhl.)

This is a shrub, three to five feet in height with straggling branches, common in moist thickets and woodlands. The flowers are greenish-yellow, three-fourths of an inch long and borne in pairs on slender stalks which are usually about half the length of the leaves. The berries also are in pairs, about one-fourth of an inch long, egg-shaped and red when ripe. It is the commonest Vermont lonicera and ordinarily apt to be confused only with the diervilla or bush honeysuckle, which is easily recognized by its toothed, long-pointed leaf as well as by its fruit, an elongated dry capsule. It is not so easy, however, to differentiate the fly honeysuckle from the swamp honeysuckle. The latter will rarely be found and then only in cold swamps. The fly honeysuckle has a longer petiole, with leaves broader and often heart shaped at the base, shorter flower stalks and separate red berries. The fly honeysuckle is sometimes used for ornamental planting, though hardly equal for this purpose to the bush honeysuckle.



FLY HONEYSUCKLE, × ½.

TARTARIAN HONEYSUCKLE. *Lonicera tartarica* L.

This is perhaps, next to the lilacs, the commonest shrub planted for ornament in Vermont. Probably through the agency of the birds, seedlings have sprung up frequently by fence rows and in waste places, sometimes appearing as if native. It is a vigorous, long-lived shrub of about the size and general habit of the lilac but with smaller leaves and branches. It well merits its place in popular favor because of its hardiness in all situations, its wealth of fragrant bloom and its loads of scarcely less attractive berries. It varies widely in color of flower and fruit. Some bushes bear creamy white, others deep pink or rose hued blossoms. The color of the berries varies with that of the flower, the white blossoms giving lighter yellow fruit, the darker flower tints being associated with a coral-red berry. The leaves vary in like relation from a lighter to a darker green.

TARTARIAN HONEYSUCKLE.
Flowering branch, × ½.

THE ELDERS. SAMBUCUS.

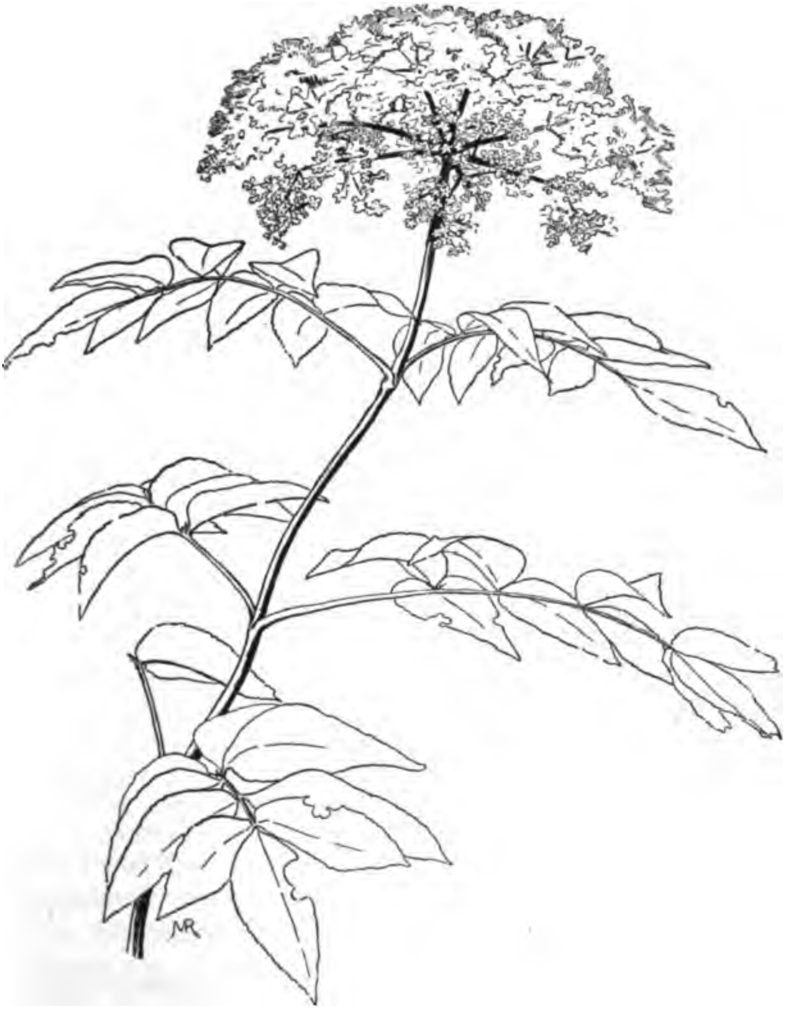
The elders are so familiar as scarcely to require description. There is however frequent confusion of the name elder and alder. Both are so common that it is only necessary to recall that the alder has simple rounded leaves and dry cone-like fruits, whereas the elders have large compound leaves and blue or red berries. This distinction is well emphasized in the common name elderberry. The two species of elder are common and both are rather coarse with a penetrating odor when bruised or cut. The leaves are large, opposite and compound with the leaflets toothed. The flowers are somewhat fragrant, white and rather small, but are borne in large showy masses. These, appearing in the earlier species in late spring and in the others in early summer, are followed in turn by the ample and richly colored fruit clusters, the one in midsummer and the other in autumn. These characteristics combine to make the elders surpass all other native shrubs in giving large and pleasing color effects to our waysides. The two elders are distinguished as follows:

Flowers in broad flat clusters in June, fruit dark purple, pith white. Common elder.

Flower clusters pyramidal in May, fruit red, pith brown. Red-berried elder.

COMMON ELDER. *Sambucus canadensis* L.

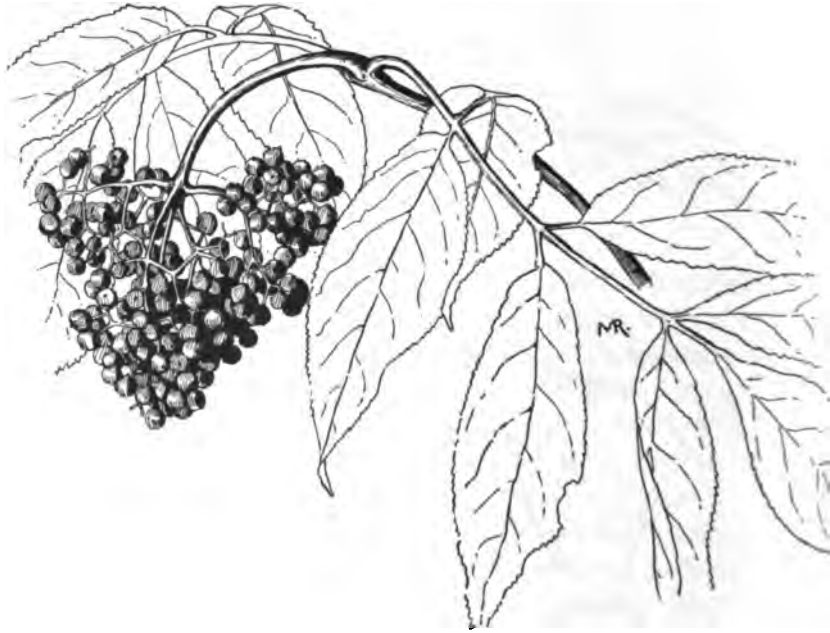
The common elder is a shrub usually five to ten feet high, which is fond of rich moist soil and plenty of sunlight, thriving in wayside thickets where its quick-growing stems soon overtop the blackberries and vie with the dogwoods. The ample flower clusters open in June and July,. just when most needed to add color to the waysides; the black-purple berries ripen in September. An English botanist, Smith, says that the "uncertain summer is established when the elder is in full flower and is entirely gone when its berries are ripe." The elder has been made useful in various ways. Emerson summarizes these as follows: "An infusion of the juice of the berries is a delicate test for acids and alkalies; an infusion of the bruised leaves is used by gardeners to expel insects from vines; a wholesome sudorific tea is made from the flowers; the unopened flower buds when pickled make an excellent substitute for capers; the abundant pith is the best substance for the pith balls used in electrical experiments; and the hollow shoots are in great use with boys for popguns and fifes." To this of course must be added the use of the ripe berries, much more common formerly than now, for elderberry wine. They were even made into pies, but there is no need of such usage to-day in view of the abundance of better fruit.



COMMON ELDER.
In flower, × ½.

RED-BERRIED ELDER. *Sambucus racemosa* L.

This is a smaller bush than the preceding, three to seven feet being its general range of height. The stem is more woody than that of the common elder, and the leaflets are downy underneath instead of being smooth. Otherwise the two species bear a general resemblance in stem and leaf characters, but the difference between the two is well marked in both flower and fruit as indicated in the key above. The red berries ripening in June form a striking contrast to the green foliage and they are soon stripped off by the birds. The berries are not poisonous as is sometimes claimed, but they are repugnant to the taste and no use is made of them. Nearly all parts of the plant have been used in compounding herb medicines, but to-day the flower buds alone are recognized by the pharmacopea as of medicinal value.



RED-BERRIED ELDER.
Fruiting branch, × ½.

ARROW-WOOD FAMILY. VIBURNUM

Several species of these common and attractive shrubs have high value for ornamental planting. They have opposite leaves, white flowers, usually in rather showy flat clusters, in some cases the marginal ones being larger, and conspicuous red or bluish berries. In noting the color of the fruit, however, it should be remembered that this often passes through intermediate reddish stages before reaching its mature color. The arrow-woods are often confused with the dogwoods from which they are distinguished by the fact that the berry contains one flattened stony seed, whereas the dogwood berries have an oval, two-celled, two-seeded stone. All the dogwoods have entire leaves whereas nearly all the viburnums have leaves more or less toothed or lobed. The name arrow-wood suggests the fact that the Indians found the straight shoots of some of these shrubs serviceable for arrow shafts.

1. **Flower clusters with some marginal flowers much larger than the rest; mature fruit red 2**

1. **Flowers all of same size in cluster; mature fruit generally blue black (red under 4) 3**

2. **Leaves with three to five heavy veins radiating from the base (palmate); coarsely 3-lobed ....High cranberry-bush.**

2. **Leaves with 1 midrib (pinnate); finely toothed.....Hobble-bush.**

3. **Leaves with three to five heavy veins radiating from the base (palmate); usually more or less 3-lobed 4**

3. **Leaves with 1 midrib (pinnate); never lobed 5**

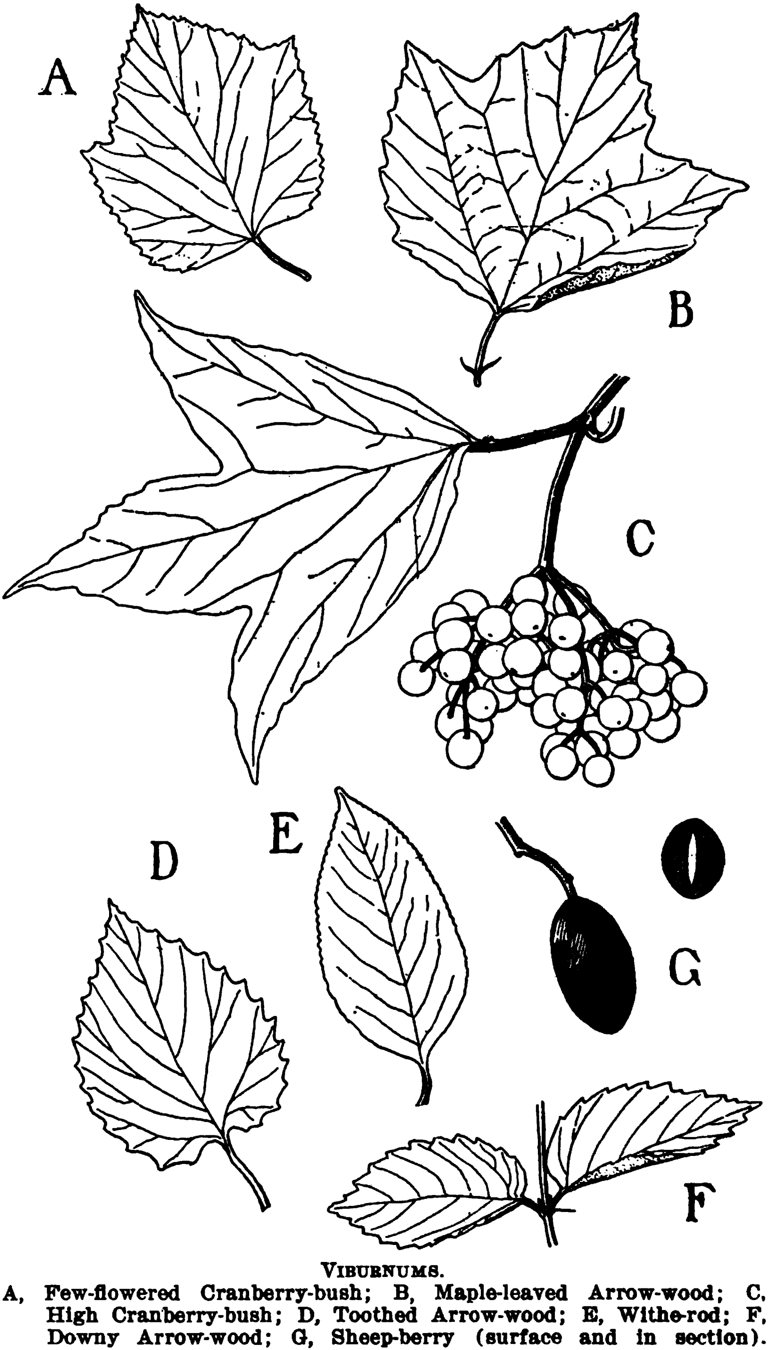
4. **Leaves soft-downy beneath; flower clusters one and one-half to two inches wide, terminal, mature berries blue-black.**
Maple-leaved arrow-wood.

4. **Leaves nearly or quite smooth beneath; flower clusters one-half to one inch wide, lateral; mature berries red.**
Few-flowered cranberry-bush.

5. **Leaves coarsely toothed 6**

5. **Leaves finely toothed or entire 7**

6. **Leaf-stalks (petioles) downy and very short (less than one-fourth inch) leaves velvety-downy especially underneath.**
Downy arrow-wood.



VIBURNUMS.

A, Few-flowered Cranberry-bush; B, Maple-leaved Arrow-wood; C, High Cranberry-bush; D, Toothed Arrow-wood; E, Withe-rod; F, Downy Arrow-wood; G, Sheep-berry (surface and in section). A-F are × ½, G is natural size.

6. **Leaf-stalks smooth and longer (one-half inch or more; leaves smooth except for some hairs about base and angles of veins underneath ....Toothed arrow-wood.**
7. **Leaves with long-tapering acute apex and sharply-toothed margins; mature berries one-half inch or more long..Sheep-berry.**
7. **Leaves with rounded or obtuse pointed apex; margins dull-toothed or entire; berries one-fourth inch long....Withe-rod.**

HIGH CRANBERRY-BUSH. *Viburnum opulus* L. var. *americanum* (Mill.) Ait.

This plant has an upright bushy habit and is from five to ten feet in height. It is scattered through swamps and low moist woodlands, especially along streams but, if transplanted, will grow well in dry soil. It is rendered conspicuous by flower, fruit and leaf. The leaves are strongly three-lobed, usually with spreading lobe-tips. The blossoms open in May or early June in clusters three to four inches across, rendered showy by the large white marginal flowers, one-half inch or more in diameter. The berries pass from a green through yellowish tints to a bright red in ripening and are not only showy during the autumn but may cling to the branches through the winter. They have a single large flat stone, a pleasant acid flavor similar to that of the true cranberry and are sometimes used as a substitute for it in sauce and pastry. Some medicinal properties are attributed to this plant. The native shrub is frequently used for ornamental planting and well deserves usage. The common snowball-bush or guelder-rose, so much grown for ornament, is a horticultural variety of this same species, but is of European ancestry. It differs only in having all the flowers of the cluster showy and sterile and hence forms no fruit.

FEW-FLOWERED CRANBERRY-BUSH. *Viburnum pauciflorum* Raf.

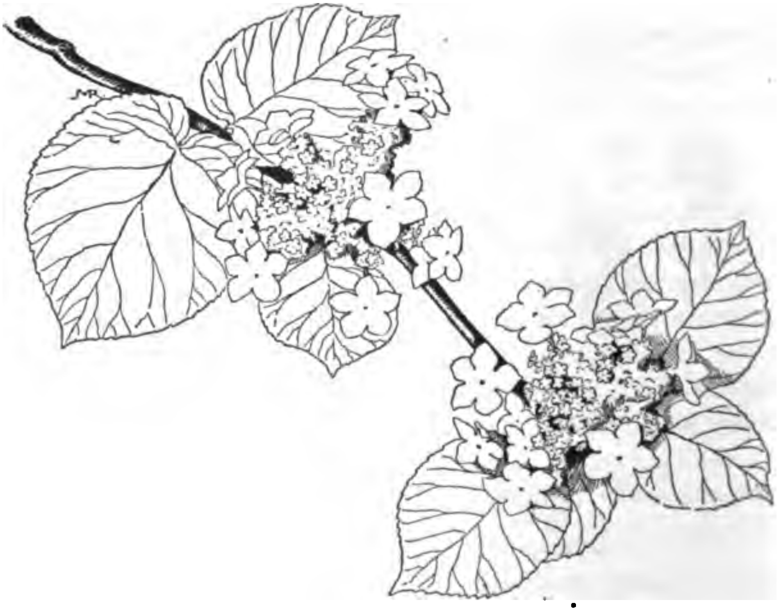
This is a sub-alpine species closely allied to the last. It is a low straggling shrub, two to four feet in height, found only on the two higher mountains, Mansfield and Killington, in the moist ravines near the limit of tree growth. No one need confuse it, therefore, with either of the species of lower altitudes. If there is doubt, the characters mentioned in the preceding key will suffice for its recognition. The berries are acid and edible though too rare to be of practical use.

HOBBLE-BUSH. *Viburnum alnifolium* Marsh.

This is also called wayfaring-tree, a name first given to an English relative. Emerson, commenting on the origin of this curious name, quotes the English poet Howitt:

"Wayfaring tree! What ancient claim
Hast thou to that right pleasant name?
....
What'er it be, I love it well;
A name methinks, that surely fell
From poet, in some evening dell,
Wandering with fancies sweet."

Hobble-bush is a name, the origin of which is quite vague. Possibly it originated from the fact that the low horizontal branches near the ground cause one to trip frequently.



HOBBLE-BUSH.
Flowering branch, × ⅛.

However, this plant is one that must be known by some name to every lover of Vermont's mountain roads. It is a low irregular shrub rising usually but a few inches from the ground. Often its forking branches are nearly or quite prostrate and, striking root, start new colonies. The leaves are few but large and unusually attractive, from the time they burst their rusty buds in spring, through their sturdy summer development to a size of four to to six inches, with dark green colors traced with the delicate network of veins, until they end with the rich reds and browns of autumn. The buds are conspicuous and attractive in winter. The blossoms, too, stand out in large clusters bordered with the larger sterile marginal flowers which are often an inch across. The rusty brown hairs coating the young shoots, flower and leaf stalks and the lower leaf surface add to the color effect, and these are still further heightened by the berries ripening from red to a rich purplish-black. They are not edible. The hobble-bush deserves a place in ornamental plantations in any cool, moist situation, but nowhere can it be so charming as when fringing a trout brook on the mountain side.

MAPLE-LEAVED ARROW-WOOD. *Viburnum acerifolium* L.

This is a low, erect shrub of three to five feet, frequently found in rocky woodlands. The leaves bear a close resemblance to the common red maple in outline, which is the more striking since both plants have opposite leaves. Closer attention suffices to remove any doubt as between these, however, since the arrow-wood leaves, especially the younger ones, are so soft-hairy beneath as to be velvety to the touch, whereas the maple leaf is smooth. The arrow-wood also flowers and fruits freely and so shows its family characters. The berries are blue-black when ripe and of disagreeable taste. This is a desirable small shrub for ornamental planting, its value being enhanced by the attractive purple hues of its autumn foliage. The name Dockmakie, probably of Indian origin, is sometimes applied to it.

DOWNY ARROW-WOOD. *Viburnum pubescens* (Ait.) Pursh.

This is a low straggling shrub with slender branches two to five feet high. It is frequent in the Champlain valley, preferring dry rocky woodlands. It is sometimes used in ornamental plantings and is to be recommended especially for dry, partially shaded banks. Its natural habitat in dry woods segregates it in nature from the next species which it most closely resembles. If, however, the two are intermingled the characters emphasized in the key will suffice to distinguish them.

TOOTHED ARROW-WOOD. *Viburnum dentatum* L.

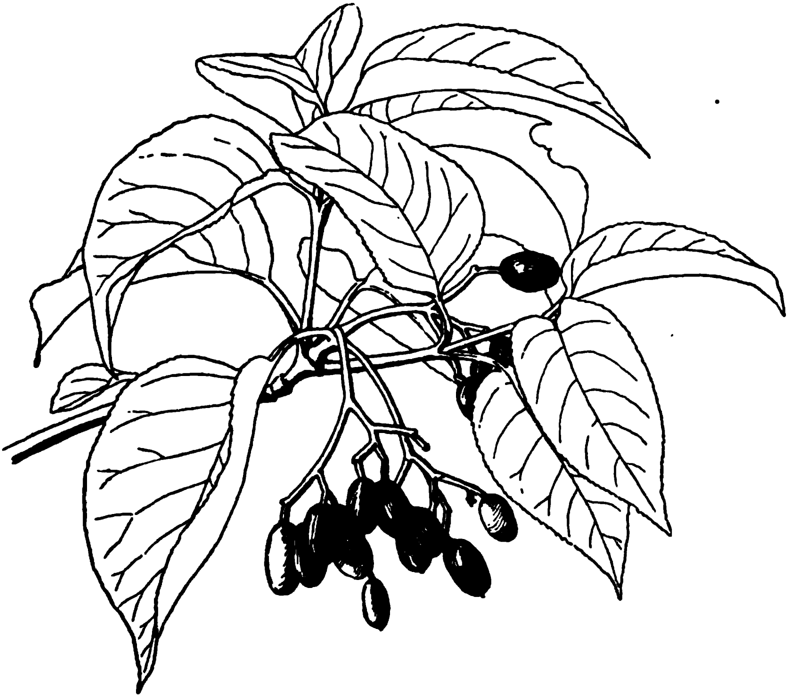
The common and latin names, of like significance, are appropriate for this shrub, the leaves of which are prominently toothed. It is said by the early botanist, Marshall, that the Indians preferred to use the young shoots of this species to those of any other of the arrow-woods for the fastening of their shafts. It is distinguished from the preceding form by its smooth branches and leaves, its larger size (five to ten feet), and its preference of moist soils. It is fairly frequent in swampy places. The flower clusters are two or three inches across, opening in early summer, and the blue-black berries, about one-fourth inch in diameter, mature in September. Although a native of wet places it will grow if planted in any good soil, and its pleasing habit and clean bright foliage combine with flowers and fruit to make it deserving of very general use in ornamental planting.

WITHE-ROD. *Viburnum cassinoides* L.

This is a common shrub in swamps throughout the state. The name withe-rod is well chosen since its long lithe stems make the best of withes. It has an erect habit from five to twelve feet high, grayish bark and young branchlets, leaf stalks and under leaf surfaces sprinkled with rusty or scurfy dots. The leaves are thickish and dull green with apex somewhat tapering but dull-pointed and with margins varying from almost entire to dull-toothed. The leaf base tapers to the leaf-stalk and even extends somewhat down it as a wing-like margin on either side. The flowers open in early summer in rounded white clusters, two or three inches across, and the berries, one-fourth inch long, ripen in September to deep blue with bloom. This is sometimes planted as an ornamental shrub though it has no conspicuous merit. The fruit has a sweetish taste and may be eaten, though few people gather it.

SHEEP-BERRY. *Viburnum lentago* L.

This shrub, known also as nanny-berry or sweet viburnum, is conspicuous in rich, moist woods, pasture thickets and along streams. Ordinarily of the size and habit of a shrub of five to ten feet, it may sometimes develop into a small tree of twelve to eighteen feet. The smaller stems and larger branches are of a



SHEEP-BERRY.
Fruiting branch, × ½.

purplish-black color; the leaves are of a rich green tint and gracefully curved, rather large, margined with small sharp teeth and tapering to an acute point. The flowers open in June in large clusters, two to five inches broad. These, and the fruit cluster following, terminate the shoots and are sessile, i. e. have no extended common stem. The berries are the largest of this group, oval, one-half of an inch or more in length, and are borne in heavy clusters which often load the branches down with their autumn weight. They pass through a rich scarlet to a shining bluish-black with a bloom when ripe. The fruit is sweet and edible, and is better after being touched by frost. The foliage shows fine autumn tints. Altogether this is to be rated as one of the most attractive of our native shrubs for large decorative effects in landscape planting.

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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 146

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The Grass and Clover Seed Trade in Vermont in 1907-1909

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[*] In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 146: THE GRASS AND CLOVER SEED TRADE IN VERMONT IN 1907-1909

By George T. Harrington

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INTRODUCTION

The author of this bulletin—a graduate of the Agricultural Department of the University in the class of 1909, and now employed in the seed laboratory of the Bureau of Plant Industry of the United States Department of Agriculture—made a study of the grass and clover seed trade of Vermont as it has obtained during recent years, submitting the results thereof in the form of the senior thesis which is a regular pre-requisite of graduation. This bulletin is an abstract therefrom. Another graduate of the same class, Miss Alma L. Carpenter, studied the history of the grass and clover seed industry of the United States, presenting this as her senior graduating thesis. Her survey of this matter is now being worked over with a view of issuing it as a bulletin from the office of the State Commissioner of Agriculture. These two bulletins will supplement each other. Arrangements have been made whereby the latter bulletin issued by the Commissioner will be sent to the entire Vermont station mailing list.

JOSEPH L. HILLS, Director.

SUMMARY

Good seed should be true to name, reasonably pure and free from foreign matter, particularly weed seeds, and should germinate well and grow vigorously.

Seed control in the United States is of two sorts; the regular inspection of the trade under station auspices, which obtains in a few states and in Canada, and the sporadic testing of samples submitted by interested parties, buyers or purchasers. The latter method is the one now in vogue in Vermont.

A survey of 131 samples sent on for examination during the past three seasons indicates that:

1. The timothy seed was usually of good grade carrying normally but few weed seeds; that

2. The red clover seed samples varied widely in quality and showed a much lower average than did the timothy, many lots being very poor and some execrable as regards their weed seed contents; that

3. The alsike clover samples were highly variable in quality, none being as good as were some red clover samples and none as poor as were some of the red clovers.

The relationship of the trade in clover seed to the Vermont weed flora, both old and new, is pointed out, as well as the fact that legal enactment in other states, and particularly in Canada, tends to flood with low grade seeds other states in which no such enactments exist.

PREVIOUS SEED STUDIES

For twenty years the Vermont station has undertaken to analyze samples of grass and clover seeds sent by purchasers or dealers within the state, and to determine their purity with special reference to their weed seed content. It has furthermore made one quite systematic inspection of the trade in this commodity as well as two briefer studies.[1] Similar work, often of greater volume, has been done at many other stations as well as by the National Department, using either seeds forwarded by interested parties or those inspected in the open market. As a result there now obtains among the better informed farmers and seed dealers a clearer appreciation of the inferiority of poor seed, a better understanding of those qualities which collectively characterize good seed, and a more general and intelligent knowledge of the relationship between the character of the seed sown and the weed problem.

It is the primary purpose of this bulletin to present and briefly to discuss the results of seed tests made at this Station since 1907, and to review the concurrent trade conditions. Incidentally are pointed out the reasons for and the necessity of such means of seed control as may afford buyers reliable information as to purity and comparative values. Furthermore and finally, the limitations of the present situation as to seed sales as they obtain in Vermont are cited, and the results compared with those attained in other states and countries where efficient seed control measures are enforced.

GOOD COMMERCIAL SEED DEFINED

Good seed should be:

(1). Of the kind and variety desired.

(2). Reasonably pure and reasonably free from foreign material.

(3). Capable of germinating well and growing vigorously.

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[1] Vt. Sta. Rpt. 11, pages 229-234 (1898); Rpt. 13, pages 287-299 (1900); Rpt. 17, pages 402-417 (1904).

(1). *Seed of the desired kind and variety.*—The importance of this matter is obvious. The buyer of clover seed cavils at the presence of material amounts of timothy which costs but half its price; and he who seeds down for market hay, using timothy as he should, decries an admixture of clover seed even though the latter is the more costly, because the presence of clover lowers the selling price of the hay. Kentucky blue grass is prized as the finest grass for lawns and pastures. A relatively high price being asked for genuine seed, it is often sophisticated, Canada blue grass (Poa compressa), an almost worthless species, being substituted in part or wholly therefor. Perhaps no other example could be cited which so well illustrates the necessity of careful expert examination. The distinctive characteristics of Kentucky and of Canada blue grass seed are sufficiently marked to admit of their certain identification by a trained analyst; yet the two are sufficiently alike and their distinctive characteristics are so apt to be overlooked, that the scrutiny of the ordinary purchaser or dealer does not detect substitution or sophistication. Roberts and Freeman[1] say that "while the ordinary observer can readily be taught to distinguish Canada blue grass from Kentucky blue grass in the field, the writers know of no really effective and satisfactory way of distinguishing the commercial seed of the two species that can be used by the ordinary purchaser. It remains in their judgment absolutely a question for the expert." Other common adulterants in commercial seed are:

Redtop chaff in Kentucky blue grass; Italian rye grass in orchard grass; rye grass in meadow fescue; bur clover and yellow trefoil in alfalfa; sweet clover and yellow trefoil in red clover. The certain detection of any of these admixtures necessitates expert observation. Unfortunately no method has been discovered save that of actual growth trials to distinguish from each other the seeds of many of the varieties of a single species, or in some cases to distinguish the seeds of separate species; as for example mammoth clover (Trifolium medium) from common red clover (Trifolium pratense).

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[1] Kans. Sta. Bul. 141, p. 108 (1907).

(2). *Purity; freedom from foreign matter.*—Three items are important in this connection; the determination of the presence, the absence, or the relative abundance of:

(a). "Inert matter" (chaff, sticks, pebbles, etc.)

(b). "Foreign seeds" (i. e., other than of the kind bought).

(c). "Pure seed" (actual kind bought).

The determination of these three items indicates the purity of the sample. The foreign seed content is usually subdivided into "weed seeds," or "noxious seeds," and "harmless seeds," the kinds and numbers of each per pound being specified.[1]

(3). *Germinability and growth.*—Quite as important as the purity of the seed supply is its germinating power, its ability, when properly sown in a well tilled field, to produce an adequate growth. Of two lots of clover; one composed of 90 percent pure seed, nine-tenths of which is germinable and 10 percent of which is made up of harmless chaff, etc.; the other composed of 100 percent pure seed, half of which is incapable of germination; the former, impure sample is to be prefered for the reason that it furnishes 81 pounds of germinable seed as against 50 pounds; that it furnishes potentially a crop larger by 62 percent; that it is worth 16 cents a pound where the second grade is worth 10 cents. Of course this argument holds only if the impurity is of a harmless character.

Buyers are apt to judge the quality, probable germination and growth of their purchases by color and appearance. Doubtless fairly reliable indications are often thus furnished; yet only actual germination tests afford absolute certainty. This fact is well illustrated by occasional lots of fine appearing red clover seed which may contain as much as 40 percent of the so-called "hard seed." The outer seed covering of this "hard seed" is so indurated as to retard the imbibation of water; hence it lies in the soil for months or years without change and consequently has relatively low agricultural values.[1]

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[1] See pages 218-219 and comments thereon.

In selecting seed, not only these three points above mentioned should be kept in mind, that is to say the proportion of actual seed true to name, its germinating powers and the purity and freedom from weed seeds, but also a fourth, viz., the "actual value" bought for a given price. The weight of true clover seed capable of germination bought for a dollar rather than the pounds of more or less pure seed purchased for that price should be the criterion. According to this measure a relatively costly seed may prove the cheapest. Yet one should not fail to remember that the financial measure is not the sole standard by which one should determine purchase. One should not buy seed, even though the price is reasonable and its germinating powers good, if it contains any material number of weed seeds.

THE WEED PROBLEM

Seed purity and germinability are important; yet the control of the weed seed situation is more so. Foreign, harmless seeds cause some slight loss, but weed seed admixtures are pestiferous. So many kinds and in such numbers occur in some poorly cleaned commercial seeds as to constitute at once a menace to good farming and a justification of the institution of a seed control. The use of seed of low germinating powers, of weak growth, or laden with inert matter, damages the one individual for one year and one crop. Not so with the use of the weed laden seed, for, generally speaking, the weed seeds thus sown are those which have matured at the same time as or slightly before the crop seed, and, being planted therewith, they are apt to continue so to do. Every weed in the meadow occupies the room which should be utilized by a more nutritious and palatable plant. It appropriates to itself the plant food and moisture which otherwise would be available to crop growth. If it matures seed, its power for evil during succeeding years is multiplied indefinitely, both to the home farm and to the neighborhood, if the seed are of the sort which are carried by winds, birds or otherwise.

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[1] Nobbe has shown that certain samples of red clover seed after 26 years' immersion in water still maintained their relatively hard character.

Weeds propagated by underground stems or rhizomes, such for example, as quack grass or witch grass[1] and orange hawkweed or paintbrush[2] are peculiarly apt to increase their ability to do harm. The persistence of witch grass and its rapid spread are the despair of the Vermont farmer; and the rapid spread of the hawk weed or paintbrush by means of a wind blown seed has carried it within a score of years to almost every part of the state.[3]

Weeds are not the private problem of the individual; they are a public nuisance, the control of which concerns all mankind and not the intelligent husbandman alone. Though other avenues of introduction exist—railroads, escaped ornamentals, etc.—the two means whereby most of the new weeds gain entrance and old weeds become more widely distributed, are commercial seeds of poor quality, and certain commercial feeding stuffs which carry unground or untreated screenings from flour mills and from the seed screening machines. The commercial seed inlet admits the greater number. All farmers must needs use seed, whereas they need not use feeding stuffs which are under suspicion. Furthermore, the feeding stuffs inspection has served, to some extent at least, to point out the sinners among feeds, whereas no such system is in vogue as to the seed trade. The relationship of the feed supply to this situation will not be further discussed in this bulletin, as it has been reviewed in detail in previous issues (bulletins 131, 133, 138, 144).

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[1] This station will shortly publish a bulletin, No. 149, dealing with a satisfactory method of combatting witch grass.

[2] See Vt. Sta. Bul. 56 (1896).

[3] See in this connection the comparatively small area in Vermont seriously infested in 1896, as indicated in bulletin 56.

SEED CONTROL

It is evident from what has been said, and in view of the fact that few men are able to judge intelligently of the comparative merits of seeds, that vigilance is needed to minimize the weed seed distribution due to the use of commercial seeds. Herein lies the value of systematic seed control. In most European countries this need has given rise to a well regulated system, whereby seed dealers voluntarily place themselves under the jurisdiction of seed testing stations, guaranteeing their products, using station tests as the basis therefor, and submitting questions arising under this system to the decision of the station as arbiter. Several of the stations in this country make free analyses of seed samples sent them for that purpose by purchasers or dealers. In a few of the states (Maine, New Hampshire, Connecticut, Kentucky, Iowa and perhaps others) more or less efficient laws are in force providing for systematic seed inspection, the aim of which is to control the local seed trade. The seed control act of Canada, passed in 1906, fixed standards for timothy, red and alsike clovers or their mixtures, sold as first quality. These must not only be of a prescribed purity and germination, but also be free from specified weed seeds. The same law prescribes that certain weed seeds—a less extensive list—must either be entirely absent from the seeds of cereals, grasses, clovers and forage plants, or that their presence must be stated on the packages. It further expressly declares, as do also the statutes of certain states in this country, in effect that "the provisions contained in this act shall not apply to seeds marked 'not absolutely clean' and held or sold for export only."[1]

Such a proviso insures the exportation of such inferior products beyond the borders of Canada, or the states or European countries thus protecting themselves. The purveyors of such seed will naturally seek an outside market for such of their wares as are too foul for home sales. Much Canadian rejected seed has been sold of late in Vermont, especially in 1907 immediately after the passage of the Canadian seed control act.

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[1] Dom. Can. Dept. Agr. Bul. 1 (revised edition) (1908).

METHODS AND LIMITATIONS OF SEED CONTROL IN VERMONT

The seed control of Europe, involving voluntary guaranties by dealers, does not obtain in America. Two situations occur here; one wherein the station merely tests such samples as are forwarded, without making an attempt at state wide inspection; and one wherein the station conducts such inspection by the collection and analysis of samples drawn in open market, on the strength of which inspection it estops illegal sales. There is no seed law on the statute books of Vermont; hence no systematic work is done. Under such circumstances the extent of the work depends upon the initiative of the individual farmer; the responsibility is lain upon the purchaser or dealer. He who sells or buys may, if he will, know as to the quality of the particular lot he has in hand. The assurance of good seed has thus been afforded in multitudinous cases, and the discovery of that of inferior quality has also been made in many cases. Many buyers accomplish this end by seeking only the best grades from reliable dealers; or else by personal examination and comparison of the various grades as found upon the market. But many less thoughtful buyers on the contrary, because either of ignorance or of carelessness, buy and sow low grade seed, large amounts of which are sold within the state, and their fields become both neighborhood eyesores and neighborhood menaces. Against such a situation he who sows good seed and strives to eradicate weeds from his farm has neither protection nor redress. Doubtless the buyers of the lower grades rarely appreciate the facts. No one deliberately buys weed seeds. The saving of money, which is the bait put forward by the seller, is what attracts. The deliberate catering to the demand for a low priced seed, with quality and purity a secondary consideration, or the equally harmful though less reprehensible policy of the purveying of foul seed through ignorance or carelessness, alike tend to spread weeds. The real fault lies with the buyer. If he get about it early enough he can determine where he may obtain really good seed; but he rarely does this. The better class of seed dealers prefer to carry the higher grades, but find it difficult to persuade farmers against the false economy of buying the lower grades. And so long as a demand exists for such it will be supplied. Per contra, when farmers will pay for better goods, dealers will gladly carry them.

The station's analytical work is of aid to the trade and to discriminating buyers only in so far as they make use of it. Its limitations and defects lie in its necessarily unsystematic character. Without legal sanction and without funds, the Station is powerless to do more than call attention to its willingness to handle samples sent by individuals, so far as lies in its power.[1] Especial attention is called however to the fourth proviso in the footnote. Samples received at the last moment before seed time, accompanied by a request for a report "by return mail," cannot be usually handled to the satisfaction of the sender. They should be sent far in advance of the time of need, and ample time allowed for the necessarily slow process of examination.

FALSE ECONOMY OF LOW GRADE SEED PURCHASES

The following instances serve to show the false economy of buying low priced and inferior seed. Doubtless red clover is the foulest seed on the Vermont market. It varies most in price as compared with grade, and represents greater ranges in quality than occur with any other widely sold commercial seed.

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[1] "Free analytical work is done without charge to the residents of the state if received not too frequently from one individual, provided: (a) the work appears to be of public benefit and the results are at the disposal of the Station to publish if it deems advisable; (b) the samples are taken in accordance with directions formulated and furnished by the Station; (c) the carriage charges are prepaid; (d) it is physically possible to do the work within a reasonable time and without serious interruption to regular and stated duties.

Agricultural seeds, as to purity: If germination tests are desired the samples, if in too large numbers, may be declined or else submitted to the Seed Laboratory of the National Department of Agriculture." Vt. Sta. Circ. 3 (1909).

Moreover its selling price is unfortunately no necessary index of its quality. Indeed, it happens not infrequently that a medium priced seed may be a cleaner and wiser purchase than is that of a relatively high priced goods. It is the quality and not the price that should be the criterion.

	Sample number		
	39	42	34
True clover seed	58.2%	63.2%	87.4%
Weed and harmless seeds	28.9%	19.9%	4.6%
Inert matter (mostly immature seed)	12.9%	16.9%	8. %
Weed seeds, per pound	49,600	36,400	15,700
Harmless seeds, per pound	160,200	98,900	15,300
Recognized varieties of weed seeds	18	25	15
Recognized varieties of harmless seeds	5	4	4

For full data see pages 222-225. "There are others" (see numbers 36, 40, 43, and others, pages 222-223).

In comparison with these products of the seed dealer's art may be placed numbers 16, 17, and 20.

	Sample number		
	16	17	20
True clover seed	99.1%	99.0%	99.2%
Weed and harmless seeds	0.1%	0.4%	0.2%
Inert matter (largely broken seed)	0.8%	0.6%	0.6%
Weed seeds, per pound	100	1,700	300
Harmless seeds, per pound	100	4,700	600
Recognized varieties of weed seeds	1	7	3
Recognized varieties of harmless seeds	1	3	1

There are plenty of others. Good seed is obtainable, if wanted.

Viewing sample 39 in another way: If 8 pounds were sown per acre there would be thus distributed:

172,000	seeds	of	barn grass (green foxtail)
59,200	"	"	sheep sorrel
51,200	"	"	pigweed (lambs' quarters)
28,800	"	"	docks
38,400	"	"	two varieties of plantain
19,200	"	"	sticky cockle (catchfly)
28,000	"	"	other weeds
396,800	weed seeds per acre		

Twenty-five thousand weeds per square rod, plants of a sort notoriously well able to thrive, owing to their early and vigorous growth. Furthermore, a nearly pure stand of grass or clover can more readily combat a few weeds than can less perfect stands wage successful war with considerable numbers.

A yet more inferior quality of seed than number 39 was recently analyzed at the United States Department of Agriculture. But half its content was true to name. It carried to the pound 199,000 harmless seeds of six varieties and 77,000 weed seeds of thirty known varieties. The germination of the true seed was 48 percent. It carried at best not more than approximately 96,000 living clover seed per pound, along with at least 37,000 weed seeds capable of thriving and nearly 100,000 of other and harmless though undesirable seed.

Goods like number 39 and the sample just cited are not commonly sold in such foul condition. They are usually recleaned by the wholesale seedsman, or used in so-called "grading down" of better material to meet market demands for a cheap seed. If recleaned, their power for evil is minimized. If used as a diluent, their power for evil is magnified, for a noxious seed is more largely distributed over a larger area and given ample opportunity for establishing itself. Much of the low grade seed is thus graded down, and is on that account more objectionable than is a low grade product grown in a given locality and not mixed with seed elsewhere grown. Seed such as is exemplified by numbers 39, 42, 34, or the department sample, is much more expensive as an initial purchase than is seed of the quality of numbers 16, 17, and 20. That is to say, the actual clover seed contained in the poorer quality costs more than does that contained in the better quality. Indeed, one may, if he will, close his eyes to the weed seed contents, and base the argument solely on the clover seed contents of the two grades, and easily prove the better to be the cheaper. Their actual values may be determined by multiplying purity percentages by germination percentages. Assuming an 80 percent germination for No. 17 (unquestionably a low estimate) and for No. 39 (doubtless a high estimate, because of the shrivelled character of the seed), and using the actual selling prices, 20 cents for No. 17 and 15 cents for No. 39, the following data are obtained:

	Sample number 17	Sample number 39	U. S. D. A. sample
Pure seed in 100 pounds	99 lbs.	58 lbs.	50 lbs.
Germination	80%	80%	48%
Germinable clover seed in 100 pounds	79 lbs.	47 lbs.	24 lbs.
Price per pound	20 cts.	15 cts.	......
Price per pound of pure seed	20.2 cts.	25.9 cts.	......
Price per pound germinable red clover seed	25⅜ cts.	32.9 cts.	......
Relative values per pound	20 cts.	11.9 cts.	6.1 cts.

In view of the fact that the actual red clover seed in number 39 and the departmental sample was shrivelled and doubtless less capable of vigorous growth than that in number 17, the above statement unquestionably overvalues the poorer products.

RESULTS OF INSPECTION

During the past three years 131 samples of seed have been sent in for report as to purity. Germination tests could not be made for lack of available appliances. These receipts consisted of the following sorts: Timothy 53 samples, red clover 43, alsike clover 18, red top, 5, alfalfa 3, oats, barley and Japanese millet, each 2, Kentucky blue grass, orchard grass, Hungarian, each 1. The detailed statement as to their purity, the percentages of foreign seed and of inert matter, and the numbers of noxious and of harmless seed per pound, with a statement of the numbers of each species and of the general grade of the seed appears on pages 218 to 226 inclusive. These somewhat formidable tables are discussed on page 217 and on pages 227 to 234 inclusive. It is realized that the small number of samples tested, 131 in all, is far from being representative of the Vermont trade in this important commodity. Yet, since the samples were received from all sections of this relatively small state, it is thought that the results obtained afford some index of the character of the trade, and that they show the common purveyal of both bad and good grades.

DISCUSSION OF RESULTS EXHIBITED IN TABLES ON PAGES 218-226

1. *Timothy* (*53 samples*).—As a whole the timothy seed was found to be of good grade. Two lots (No. 6 of 1907 and No. 191 of 1909) carried respectively 13,000 and 21,000 weed seeds per pound. But one other lot (No. 119 of 1908) carried in excess of 3,000. In 1907 two lots carried more than one percent impurities; in 1908 four lots; in 1909 three lots; or a total of about one in six. Only two lots carried more than 1.4 percent impurities; but, as above remarked, these were bad ones. The quality of the 1909 goods, so far as may be judged by the limited number of samples inspected, was somewhat inferior to that of the two preceding years. Considerable ergotized seed was observed, however, in 1908, although the average seed under survey that year showed higher purity than did that sold in either of the other years. An ergotized seed is undesirable but it is not a serious menace. The fruiting bodies of ergot grow in nearly all fields and their relative amount and vigor are largely dependant upon meteorological conditions. Hence the use of an ergotized seed does not create but simply augments the danger. One lot (No. 118) contained a few seed of field dodder, a most objectionable weed rarely found in timothy but all too common in clover and alfalfa.

Timothy seed is commonly marketed in good condition. The crop is usually grown in pure stand, seeds abundantly, and is readily harvested, cured, and cleansed. Hence it is easy to produce a high grade seed at a low price; yet farmers and dealers alike seem to be watching the quality of timothy seed more carefully than that of any other crop. This is doubtless due in part to its very general use. It is not suggested that less vigilance be employed in this respect, but that more care be exercised in the purchase of clover seed.

Timothy seed carries few weed seeds. This is a matter of common knowledge and is abundantly borne out in the results reported herewith. Only 26 species of weed seeds were iden-

TESTS OF TIMOTHY SEED

							NOXIOUS SEED (Hundreds)		
Sample number	Pure seed, percent	Foreign seed, percent	Inert matter, percent	Noxious seed, per pound, hundreds	Harmless seed, per pound hundreds	Grade	Red stemmed plantain, hundreds	Five finger, hundred	Common plantain hundreds
4	99.3	0.2	0.5	4	6	G	4	..	..
5	99.6	0.2	0.2	4	12	G	..	2	..
6	94.8	3.1	2.1	130	1034	L	16	68	13
7	99.8	0.1	0.1	2	4	E	..	..	2
8	99.9	...	...	2	..	E	..	..	2
9	99.1	0.6	0.3	20	52	G	16	4	..
10	99.8	0.1	0.1	..	4	E	..	..	..
15	99.3	0.2	0.5	4	14	G	2	..	..
18	99.5	0.3	0.2	8	17	G	2	2	....
21	99.6	...	0.4	..	..	E	..	..	..
30	99.8	0.1	0.1	..	6	E	..	..	..
33	99.3	0.4	0.3	16	40	G	7	7	..
35	99.3	0.4	0.3	13	30	G	4	..	..
37	99.8	0.1	0.1	2	11	E	..	2	..
44	99.1	0.6	0.3	2	47	G	2	..	..
47	99.8	0.1	0.1	2	4	G	..	..	..
48	99.6	0.2	0.2	6	12	G	..	..	..
52	98.6	0.6	0.8	16	43	G	..	9	..
60	99.3	0.2	0.5	2	45	G	..	..	..
62	99.8	...	0.2	..	..	G	..	..	..
77	99.4	0.2	0.4	9	4	G	7	..	..
78	98.9	0.7	0.4	29	25	F	18	..	..
89	99.8	...	0.2	2	2	E	..	..	..
93	98.6	0.6	0.8	4	56	F	..	..	..
96	99.7	0.1	0.2	2	7	E	..	..	..
98	98.6	1.1	0.3	19	60	F	9	2	..
100	99.5	0.3	0.2	26	2	G	7	..	..

NOTE. The numbers of seeds as shown in the table are expressed as hundreds, omitting the tens and units; thus, for example, the number 16 under the caption red stemmed plantain means that there were present in a pound of the seed under examination sixteen hundred (1600) seed of this particular weed.

TESTS OF TIMOTHY SEED

NOXIOUS SEED (Hundreds)							HARMLESS SEED (Hundreds)			
Yellow daisy, hundreds	Lamb's quarters, hundreds	Peppergrass, hundreds	Evening primrose, hundreds	Sheep sorrel, hundreds	Sedges, hundreds	Miscellaneous seeds, hundreds (See footnote)	Red clover, hundreds	Alsike clover, hundreds	White clover, hundreds	Redtop, hundreds
..	..	..	..	..	..	*	..	2	2	2
2	..	..	..	..	..		..	4	2	4
22	..	..	..	7	..	2a,2b	2	39	13	980
..	..	..	..	..	..		2	2	..	..
..	..	..	..	..	..		..	..	..	..
..	..	..	..	..	..		2	27	16	7
..	..	..	..	..	..		2	..	2	..
2	..	..	..	..	..		..	14	..	..
2	2	..	..	..	..		..	9	4	4
..	..	..	..	..	..		..	..	..	..
..	..	..	..	..	..		2	..	2	2
2	..	..	..	..	..		2	7	4	27
..	..	..	..	2	7		9	14	7	..
..	..	..	..	..	..		..	2	2	7
..	..	..	..	..	..		..	45	2	..
..	..	..	2	..	..		..	..	..	4
..	..	..	2	..	..	2c,2d	4	4	4	..
7	..	..	..	..	..		7	11	9	16
..	..	2	..	..	..		..	2	..	43
..	..	..	..	..	..		..	..	..	..
..	2	..	..	..	..		..	4	..	..
..	7	2	..	..	2		18	7	..	..
..	..	..	..	..	..	2e,*	2	..	..	..
..	2	2	..	..	..	*	..	20	13	23†
..	2	..	..	..	..		..	..	7	..
4	..	4	..	..	..		13	43	4	..
..	4	9	..	..	..	4f,2g	..	2	..	..

Grade marks—E excellent, G good, F fair, P poor.

*Inert matter contains ergotized seed; †Canada blue grass; a, Docks; b, Chickweed; c, Spring amaranth; d, Healall; e, Crabgrass; f, Dog fennel; g, Canada thistle; h, Mullein; i, Vervain; k, Field dodder; l, Ribgrass; m, Hedge mustard; n, Lady's thumb: o, Green foxtail.

TESTS OF TIMOTHY SEED

							NOXIOUS SEED (Hundreds)			
Sample number	Pure seed, percent	Foreign seed, percent	Inert matter, percent	Noxious seed, per pound, hundreds	Harmless seed, per pounds, hundreds	Grade	Red stemmed plantain, hundreds	Five finger, hundred	Common plantain hundreds	Yellow daisy, hundreds
102	99.6	0.1	0.3	11	7	G	2	2	..	..
106	99.3	0.5	0.2	6	44	G	..	..	..	..
110	99.7	0.1	0.2	..	13	E	..	..	..	..
111	99.8	..	0.2	..	..	E	..	..	..	..
117	99.1	0.5	0.4	19	27	G	9	..	..	..
118	99.5	0.1	0.4	6	9	E	..	..	..	..
119	98.8	0.5	0.7	31	42	G	..	12	4	..
120	99.8	0.1	0.1	2	..	E	..	..	..	..
122	99.9	..	0.1	..	2	E	..	..	..	..
124	99.5	0.3	0.2	8	22	G	4	2	..	..
136	99.7	0.1	0.2	4	..	E	..	..	..	..
137	99.3	0.2	0.5	15	14	G	..	..	..	..
138	99.3	0.4	0.3	16	22	G	..	..	7	..
189	98.9	0.6	0.5	9	29	G	7	..	..	..
190	99.5	0.1	0.4	..	2	E	..	..	..	..
191	92.8	4.9	2.3	210	241	L	101	45	18	4
192	99.1	0.5	0.4	..	22	G	..	..	..	..
193	98.7	0.7	0.6	9	22	G	..	..	7	..
196	99.9	..	..	4	..	E	2	..	..	..
197	99.9	..	..	2	2	E	..	..	..	..
198	99.6	0.2	0.2	6	8	E	..	..	2	..
207	99.5	0.2	0.3	4	11	E	2	..	..	..
209	99.6	0.1	0.3	..	4	E	..	..	..	..
210	99.5	0.2	0.3	8	9	G	..	..	2	..
211	99.0	0.3	0.7	4	9	G	..	..	..	..
216	99.2	0.2	0.6	6	7	G	4	..	..	..

NOTE. The numbers of seeds as shown in the table are expressed as hundreds, omitting the tens and units; thus, for example, the number 16 under the caption red stemmed plantain means that there were present in a pound of the seed under examination sixteen hundred (1600) seed of this particular weed.

TESTS OF TIMOTHY SEED

NOXIOUS SEED (Hundreds)						HARMLESS SEED (Hundreds)				
Lamb's quarters hundreds	Peppergrass, hundreds	Evening primrose, hundreds	Sheep sorrel, hundreds	Sedges, hundreds	Miscellaneous seeds, hundreds (See footnote)	Red clover, hundreds	Alsike clover, hundreds	White clover, hundreds	Redtop, hundreds
..	..	..	..	..	7h	..	..	..	7
..	..	..	..	..	2b,4l*	4	38	..	2
..	..	..	..	..	*	7	2	4	..
.	..	..	..	..	*	..	..	..	..
2	2	4	..	..	..	9	18	..	..
..	..	4	..	..	2k	..	9	..	..
7	..	..	4	2	2l	2	9	4	27
..	..	..	2	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	2
..	..	..	..	..	2l	2	7	13	..
..	..	2	..	..	2m*	..	..	..	..
9	..	..	..	..	4f, 2l	..	7	7	..
..	2	7	..	..	..	2	18	2	..
..	..	..	2	..	..	..	29	..	..
..	..	..	..	..	..	..	..	2	..
..	4	..	14	..	7l,4e,2d,9n,2o	43	137	67	..
..	..	..	..	..	..	..	22	..	..
..	..	..	..	..	2n	22	..	..	..
..	..	2	..	..	..	..	..	..	..
..	..	2	..	..	..	..	2	..	..
..	..	..	2	2	..	4	4	..	..
..	..	..	..	2	..	7	..	4	..
..	..	..	..	..	..	..	..	4	..
..	4	..	..	..	2a	2	..	7	..
2	..	..	..	..	2o	2	7	..	..
..	2	..	..	..	..	..	7	..	..

Grade marks—E excellent, G good, F fair, P poor.

*Inert matter contains ergotized seed; †Canada blue grass; a, Docks; b, Chickweed; c, Spring amaranth; d, Healall; e, Crabgrass; f, Dog fennel; g, Canada thistle; h, Mullein; i, Vervain; k, Field dodder; l, Ribgrass; m, Hedge mustard; n, Lady's thumb; o, Green foxtail.

TESTS OF RED CLOVER SEED

Sample number	Pure seed, percent	Foreign seed, percent	Inert matter, percent	Noxious seed, per pound, hundreds	Harmless seed, per pound, hundreds	Grade	NOXIOUS SEED (Hundreds)									
							Green foxtail	Ribgrass	Red stem plantain	Sheep sorrel	Nightflowering catchfly	Lambsquarters	Old witch grass	Slender crabgrass	Curled dock	Yellow foxtail
2	99.0	0.4	0.6	4	19	G	..	..	..	..	..	..	..	..	4	..
11	91.5	5.1	3.4	104	353	P	..	9	3	5	..	4	..	..	14	..
13	96.3	2.4	1.3	14	99	F	..	2	5	..	..	..	..	..	1	..
16	99.1	0.1	0.8	1	1	E	..	..	..	..	..	..	..	..	1	..
17	99.0	0.4	0.6	17	47	G	3	..	2	4	..	..	..	..	3	..
20	99.2	0.2	0.6	3	6	E	1	..	1	1	..	..	..	..	..	..
22	99.2	0.2	0.6	5	1	E	3	..	..	..	..	..	..	..	..	..
32	99.2	0.3	0.5	10	1	E	5	..	3	..	..	..	1	..	..	..
34	87.4	4.6	8.0	157	153	P	35	36	23	9	5	8	3	20	5	..
36	88.4	5.5	6.1	152	184	P	38	27	20	10	3	10	8	17	5	..
39	58.2	28.9	12.9	496	1602	P	215	14	34	74	24	64	..	1	..	5
40	75.0	15.0	10.0	347	527	P	137	16	39	10	19	38	10	4	15	..
42	63.2	19.9	16.9	364	989	P	89	23	38	9	66	26	7	7	34	5
43	75.3	18.0	6.7	191	1225	P	24	14	16	33	20	11	2	9	..	2
46	91.2	5.5	3.3	73	382	P	2	2	9	32	3	1	..	7	..	..
50	86.1	5.0	8.9	87	223	P	48	15	..	2	4	8	..	..	..	..
51	86.8	6.6	6.6	63	171	P	6	1	22	2	..	3	5	17	2	..
76	96.5	1.6	1.9	42	53	F	1	36	..	..	..	..	..	..	..	..
79	97.8	0.7	1.5	8	44	G	1	1	..	1	..	1	..	1	..	..
81	98.8	0.4	0.8	7	2	E	1	..	..	..	..	..	..	..	4	..
88	97.4	1.3	1.3	51	17	F	3	36	1	..	..	..	4	2	..	..
90	99.0	0.5	0.5	11	1	E	..	..	..	..	..	..	1	..	..	..
91	97.0	0.5	2.5	14	3	E	8	..	..	..	..	..	..	..	..	2
92	97.5	0.4	2.1	9	3	E	1	1	..	..	1	4	..	..	..	1
95	90.9	6.5	2.6	198	187	P	50	24	22	9	14	4	20	8	3	3
97	96.1	1.3	2.6	48	20	F	9	17	2	..	..	1	7	3	..	3
107	84.0	12.8	3.2	349	558	P	125	32	14	5	13	39	13	8	7	3

Grade marks—E excellent, G good, F fair, P poor.

NOTE. The numbers of seeds as shown in the table are expressed as hundreds, omitting the tens and units; thus, for example, the number 16 under the caption red stemmed plantain means that there were present in a pound of the seed under examination sixteen hundred (1600) seed of this particular weed.

The inert matter was quite commonly made up of dirt, chaff, sticks, straw, etc. In the cases cited below more or less seed was found in the conditions indicated.

Wormy and broken 11, 12, 126, 127, 128
Large, broken..........16, 20, 79, 80, 81, 88, 91, 92, 95, 97, 103, 107, 108, 109, 115, 130, 141, 143, 144, 199, 202, 208, 212, 213
Flat, immature 34, 39
Broken, immature 51, 94, 159, 195
Shrivelled, shrunken 36, 45, 46, 49, 135, 188, 214, 218
Shrunken and sprouted 99
Dried up 43
Ergotized 116, 145, 206
"Poor" 40, 42, 50

TESTS OF RED CLOVER SEED

NOXIOUS SEED (Hundreds)																HARMLESS SEED (Hundreds)			
Lady's thumb	Dog fennel	Plantains	Crabgrass	Kale	Yellow trefoil	Spiny sida	Docks	Panicums	Peppergrass	Ragweed	Five finger	Spurge	Red root plantain	Healall	Miscellaneous seeds (see footnote)	Alsike clover	White clover	Timothy	Miscellaneous
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		13	4	2	..
..	3	3	..	..	..	..	..	4	..	..	..	..	..	..	58A,1B	13	99	241	..
..	..	1	..	..	..	..	..	4	..	..	..	..	..	..	1C	38	24	36	1*
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		1	..	..	..
1	..	..	..	1	..	..	..	3	..	..	..	..	..	..		3	24	20	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		6	..	..	..
..	..	..	..	..	..	..	2	..	..	..	..	..	..	..		..	..	1	..
..	..	..	..	..	..	..	..	..	..	1	..	..	..	..		..	..	..	..
4	5	1	..	..	..	..	..	..	1	1	..	..	..	..	1D	43	30	79	1†
..	9	1	..	..	..	..	2	..	..	..	..	..	..	..	2E	35	50	97	2‡
5	1	..	..	10	..	..	36	..	3	..	1	..	..	..	(I)	772	118	700	8*4†
20	1	..	..	5	..	..	19	..	..	..	..	..	..	..	(II)	136	37	356	..
12	4	1	..	5	25	..	..	..	1	..	..	1	..	..	(III)	361	85	540	3*
8	18	..	..	3	1	..	17	..	..	1	..	5	..	..	5I,1J,1K	425	194	606	..
..	5	..	..	..	..	..	..	..	1	..	..	..	..	..	3R,2F,1S	127	128	126	1†
2	2	..	..	..	5	..	..	..	..	..	..	..	..	..	1J	78	34	110	1†
1	..	..	..	..	..	..	..	..	..	..	..	..	2	1	1T	28	34	106	2†1‡
..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	3U,1V	..	..	53	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1J	17	3	24	..
..	..	..	..	..	..	..	..	..	..	2	..	..	..	..		1	..	1	..
1	..	..	..	..	..	..	..	..	..	..	..	1	1	..	2W	4	..	13	..
..	..	..	..	..	..	10	..	..	..	..	..	..	..	..		1	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2A,2X	..	..	..	3‡
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1Y	..	..	..	3‡5¶
..	..	6	7	..	5	..	..	..	1	..	..	3	..	..	(IV)	53	37	90	2‡
..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	2f,1W	..	..	..	..
14	8	11	5	6	3	1	7	3	3	1	..	..	..	..	(V)	..	..	..	..

*German millet. †Red top. ‡Alfalfa. ¶Meadow fescue. §Canada blue grass.

A, Sweet clover; B, Goat's rue; C, Bracted plantain; D, Bitter sweet; E, Low amaranth; F, Canada thistle; G, Chickweed; H, Black mustard; I, Arrowhead tearthumb; J, Catnip; K, Vervain; L, Smartweed; M, Wild buckwheat; N, Dotted smartweed; O, Spring amaranth; P, Quack grass; Q, Centaurea sp.; R, Three-seeded mercury; S, Nettle; T, Suckling clover; U, Chicory; V, Wild carrot; W, German knotgrass; X, Scentless camomile; Y, False flax; Z, Prairie ribroot.

a, Slender paspalum; b, Pennyroyal; c, Barn-yard grass; d, Mint; e, Nightshade; f, Bitter dock; g, Bladder ketmia; h, Bur clover; i, Polygonum sp.; j, Shepard's purse; k, Ox-eye daisy; l, Sprouting crab grass; m, Ground cherry; n, Field bind weed; o, Bull thistle; p, Pennycress; q, Coral berry; r, sedge; s, Hedge mustard; t, Balm; u, Bromegrass; v, Purslane; w, Evening primrose; x, Yellow rocket; y, White top.

39 (I) 4F, 8L, 8E, 1G, 1A; 40 (II) 3E, 2M, 1N, 1O, 1P; 42 (III) 3E, 2L, 1Q, 1K, 1J, 1O, 1B; 95 (IV) 5Z, 5a, 2b, 2C, 2c, 2d, 1W, 1e; 107 (V) 5Z, 4F, 3c, 1G, 1e, 1a, 1g, 1W, 1N, 1r; 109 (VI) 4h, 2W, 2a, 1Z; 126 (VII) 7l, 5W, 4C, 3m, 1R, 1n; 127 (VIII) 9l, 7W, 5C, 3o, 3c, 1p, 1n, 1N, 1q, 1h.

TESTS OF RED CLOVER SEED

NOXIOUS SEED (Hundreds)

Sample number	Pure seed, percent	Foreign seed, percent	Inert matter, percent	Noxious seed, per pound, hundreds	Harmless seed, per pound, hundreds	Grade	Green foxtail	Ribgrass	Red stem plantain	Sheep sorrel	Nightflowering catchfly	Lambsquarters	Old witch grass	Slender crabgrass	Curled dock	Yellow foxtail
108	97.6	0.3	2.1	12	..	E	3	3	..	..	..	..	..	..	..	..
109	97.1	1.8	1.1	94	5	F	51	6	..	..	..	..	1	11	1	5
116	94.0	4.1	1.9	85	241	P	16	7	23	11	2	5	1	5	5	1
126	85.2	11.8	3.0	312	559	P	103	32	20	8	9	27	5	14	..	7
127	83.5	11.9	4.6	249	516	P	138	29	9	9	14	34	6	7	4	5
130	83.4	11.8	4.8	248	397	P	99	2	9	11	4	23	..	4	56	7
135	98.3	0.2	1.5	9	7	E	1	..	5	..	..	1	..	..	..	..
159	98.7	0.4	0.9	21	4	G	8	..	9	..	..	..	..	..	1	..
188	99.0	0.2	0.8	1	10	E	1	..	..	..	..	..	..	..	..	..
195	99.0	0.3	0.7	4	9	E	3	..	..	..	..	..	..	..	..	..
199	99.3	...	0.7	2	..	E	..	..	..	..	..	..	..	..	..	..
202	94.8	3.3	1.9	86	169	P	21	7	22	7	5	..	5	..	5	3
208	99.5	...	0.5	1	1	E	..	..	..	..	..	..	..	..	..	..
212	99.5	...	0.5	1	..	E	1	..	..	..	..	..	..	..	..	..
213	99.5	0.1	0.4	2	1	E	1	..	..	..	..	..	..	..	..	1
214	97.8	1.4	0.8	52	38	G	12	9	13	5	1	1	..	2	2	..
	ALSIKE.															
1	93.0	4.0	3.0	2	521	G	..	..	..	2	..	..	..	..	..	..
12	89.7	8.5	1.8	149	813	P	..	..	..	103	..	..	..	..	..	..
14	96.2	1.9	1.9	32	157	F	..	..	..	23	9	..	..	..	..	..
19	98.9	0.6	0.5	7	42	G	..	..	..	..	..	..	..	..	..	..
38	6.36	19.0	17.4	140	1728	P	2	..	..	70	16	13	..	..	2	..
45	97.1	1.0	2.5	..	4	E	..	..	..	..	..	..	..	..	..	..
49	91.0	6.4	2.6	40	565	F	..	..	..	18	9	..	..	..	..	13
53	71.2	22.9	5.9	116	2100	P	..	..	2	91	..	..	..	4	..	..
94	85.5	13.5	1.0	75	1498	P	..	4	2	41	2	..	..	..	..	..
99	85.7	12.6	1.7	199	1047	P	..	4	4	52	9	4	..	..	4	..
101	99.3	0.2	0.5	4	10	E	..	..	..	..	..	..	2	..	..	..
128	78.2	18.5	2.3	127	2700	P	2	..	9	27	..	2	..	2	..	..
140	93.4	4.1	2.5	105	327	P	..	4	..	83	..	..	..	..	..	..
187	95.6	2.1	2.3	69	147	F	..	..	..	65	..	2	..	..	..	..
194	93.7	4.6	1.7	40	496	F	..	..	..	9	..	27	..	..	..	..
200	99.0	0.6	0.4	2	61	E	..	..	..	..	..	..	..	..	..	..
201	98.4	1.2	0.4	9	83	G	..	..	..	..	..	..	..	..	..	..
217	97.8	1.5	0.7	2	159	G	..	..	2	..	..	..	..	..	..	..

Grade marks—E excellent, G good, F fair, P poor.

NOTE. The numbers of seeds as shown in the table are expressed as hundreds, omitting the tens and units; thus, for example, the number 16 under the caption red stemmed plantain means that there were present in a pound of the seed under examination sixteen hundred (1600) seed of this particular weed.

TESTS OF RED CLOVER SEED

NOXIOUS SEED (Hundreds)																HARMLESS SEED (Hundreds)			
Lady's thumb	Dog fennel	Plantains	Crabgrass	Kale	Yellow trefoil	Spiny sida	Docks	Panicums	Peppergrass	Ragweed	Five finger	Spurge	Red root plantain	Healall	Miscellaneous seeds (see footnote)	Alsike clover	White clover	Timothy	Miscellaneous seeds
..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	4h,1i	..	..	..	..
..	..	..	5	..	..	2	..	..	..	..	..	1	2	..	(VI)	..	..	5	..
..	..	5	..	1	..	..	..	..	..	..	..	..	..	..	1W,1j,1k	39	89	113	..
15	9	12	14	7	1	2	3	..	1	1	1	..	1	..	(VII)	83	184	292	..
14	9	6	8	4	2	2	4	4	4	2	..	..	2	1	(VIII)	67	160	289	..
9	..	..	..	..	..	..	9	..	2	..	..	..	..	..	9H,4i	88	16	286	7‡
..	..	..	2	..	..	..	..	..	..	..	..	..	..	..		4	1	2	..
..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	1c	..	..	4	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		1	..	9	..
..	..	..	..	..	..	..	1	..	..	..	..	..	..	..		2	..	7	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1V	..	..	..	..
3	.. •	..	1	..	..	1	..	..	..	..	..	2	3	1		19	40	110	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1V	1	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..	1	..	..
..	..	..	..	..	..	..	1	..	1	..	..	1	..	..	3s,1V	5	20	13	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		Red	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		4	27	472	18†
..	4	7	..	..	..	..	16	4	..	..	4	..	..	..	9G,2t	23	..	790	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		9	..	148	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1f	..	13	29	..
..	2	..	..	..	16	..	4	..	13	..	..	..	..	..	2F	159	241	131	18†
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..	4	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		9	250	295	11†
..	13	..	..	..	2	..	..	..	..	..	2	..	..	..	2F	55	788	1257	..
..	..	4	..	..	7	..	..	..	2	..	7	..	..	..	2r,2s,2u	11	423	1060	4†
..	..	32	..	..	43	..	..	..	18	..	..	..	..	..	27G,4r	59	329	650	9†
..	..	..	..	..	..	..	2	..	..	..	..	..	..	..		2	4	4	..
..	2	11	..	..	..	..	..	2	7	..	27	..	7	..	20v,7r,2w	16	263	2358	63† 2†
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16x,2y	34	61	158	72§
..	2	..	..	..	..	..	..	..	..	..	..	..	..	..		11	102	34	..
..	4	..	..	..	..	..	..	..	..	..	..	..	..	..		11	83	402	..
..	..	..	..	..	2	..	..	..	..	..	..	..	..	..		..	41	20	..
..	..	..	..	..	7	..	2	..	..	..	..	..	..	..		13	38	32	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		4	133	20	2†

•German millet. †Red top. ‡Alfalfa. ¶Meadow fescue. §Canada blue grass.

A. Sweet clover; B, Goat's rue; C, Bracted plantain; D, Bitter sweet; E, Low amaranth; F, Canada thistle; G, Chickweed; H, Black mustard; I, Arrowhead tearthumb; J, Catnip; K, Vervain; L, Smartweed; M, Wild buckwheat; N, Dotted smartweed; O, Spring amaranth; P, Quack grass; Q, Centaurea sp.; R, Three-seeded mercury; S, Nettle; T, Suckling clover; U, Chicory; V, Wild carrot; W, German knotgrass; X, Scentless camomile; Y, False flax; Z, Prairie ribroot.

a, Slender paspalum; b, Pennyroyal; c, Barn-yard grass; d, Mint; e, Nightshade; f, Bitter dock; g, Bladder ketmia; h, Bur clover; i, Polygonum sp.; j, Shepard's purse; k, Ox-eye daisy; l, Sprouting crab grass; m, ground cherry; n, Field bond weed; o, Bull thistle; p, Pennycress; q, Coral berry; r, sedge; s, Hedge mustard; t, Balm; u, Bromegrass; v, Purslane; w, Evening primrose; x, Yellow rocket; y, White top.

TESTS OF MISCELLANEOUS SEEDS

Sample number	Pure seed, percent	Foreign seed, percent	Inert matter, percent	Noxious seed, per lb., hundreds	Harmless seed, per lb., hundreds	Grade	Noxious seed of sundry sorts, hundreds (see footnote)	Harmless seed of sundry sorts, hundreds
RED TOP								
3	90.6	0.4	9.0	5	59	E	5A	59o
31	95.0	0.4	4.6	57	50	E	32B,5C,5D,5E,5F,5G	50o
41	88.2	2.9	8.9	885	540	P	758H,100B,27I	540o
145	92.0	2.4	5.6	23	298	G	18K,5L	270o,23p,5q
206	77.4	10.6	12.0	388	2235	P	234H,63K,50F,13M,9C,5G,9B,5N	2230o,5p
ALFALFA								
80	99.1	...	0.9	2	..	E	2L	
115	97.3	0.1	2.6	3	..	E	1O,1P,1Q	
218	95.6	0.4	4.0	10	3	E	4R,2S,2T,1M,1V	3r
OATS								
103	94.0	4.3	1.7	1—	6+	E	V and W	4t,2u
146	96.7	1.5	1.8	1—	1—	E	X and R	t,w&x
BARLEY								
143	96.5	2.5	1.0	1—	5	E	W, Y and V	3z,1x,1t
144	95.0	4.7	0.3	..	11	E		10z,1t
JAPANESE MILLET								
87	90.1	9.4	0.5	127	..	G	59R,37Y,21Z,10a	
142	91.8	5.4	2.8	123	2	G	53R,20b,19c,15d,9Y,3e,2f,1T,1g	2y
KENTUCKY BLUE GRASS								
204	93.4	0.4	6.2	45	..	E	36K,9h	
ORCHARD GRASS								
205	89.4	2.5	8.1	148	67	G	119i,14X,11k,4M	67w,2q
HUNGARIAN								
141	95.5	2.8	1.7	104	1	G	50T,14l,12R,10m,6c,5O,3n,3f,1Y	1s

Grade marks—E excellent, G good, F fair, P poor.

NOTE. The numbers of seeds as shown in the table are expressed as hundreds, omitting its tens and units; thus, for example, the number 16 under the caption red stemmed plantain means that there were present in a pound of the seed under examination sixteen hundred (1600) seed of this particular weed.

A, Sage brush; B, Yarrow; C, Yellow daisy; D, Goldenrod; E, Sheep sorrel; F, Red stem plantain; G, Peppergrass; H, Five finger; I, Common plantain; K, Sedge; L, Dog fennel; M, Ribgrass; N, Mint; O, Lamb's quarters; P, Curled dock; Q, Slender melilot; R, Yellow foxtail; S, Chicory; T, Green foxtail; U, Dock sp.; V, Kale; W, Wild buckwheat; X, Chess; Y, Ragweed; Z, Polygonum sp.

a, Smartweed; b, Spiny sida; c, Barnyard grass; d, Crabgrass; e, Large smartweed; f, Slender crabgrass; g, Spurge; h, Mouse-ear chickweed; i, Velvet grass; k, Ox-eye daisy; l, Lady's thumb; m, Old witch grass; n, Red root pigweed; o, Timothy; p, White clover; q, Red clover; r, Crimson clover; s, Alsike clover; t, Wheat; u, Barley; v, Flax; w, Bluegrasses;

tified in the 53 samples, while the unidentified seeds—perhaps half a dozen in number—were negligible in point of quantity. But one sample in 53 contained the seeds of weeds not already well established and widely known throughout the state. This one contained the seeds of spring amaranth, slender crab grass and field dodder in small quantities. The weeds occurring most commonly and in the greatest numbers were:

Common or native plantain	17
Red stem or Rugel's plaintain	38
Five finger or cinquefoil	23
Yellow daisy or black-eyed Susan	16
Sheep or field sorrel	11
Lamb's quarters or pigweed	19
Sedge or swale grass	11
Peppergrass	16
Evening primrose	16

The following tabular statement shows the weed seeds most abundantly found in timothy samples. It will be noted that numbers 6 and 191, characterized at the opening of this section are the ones in which the most common and pernicious weeds were most largely found.

WEED SEEDS IN TIMOTHY SEED

Name of weed	Number of samples in which it occurred.	Percent of samples in which it occurred.	Maximum number per pound in any sample.	Samples in which it occurred in largest numbers.
Red stem plantain	20	38	10,500	No. 191
Five finger	12	23	4,500	No. 191
Common plantain	8	15	1,800	No. 191
Yellow daisy	8	15	2,200	No. 6
Lamb's quarters	10	19	900	No. 137
Peppergrass	7	13	900	No. 100
Evening primrose	7	13	700	No. 138
Sheep sorrel	6	11	1,400	No. 191
Sedge	6	11	700	No. 35

2. *Red clover (43 samples).*—These varied widely in quality and showed a much lower average therein than did the timothy seed. This statement holds both as regards purity percentages and as regards their weed seed contents. Thirty-nine samples of red and four of mammoth clovers were examined, more than three-fourths of them during 1907 and 1908. Apparently the general quality improved markedly in 1909, for the average data for purity in round figures are: 1907, 17 samples 88 percent; 1908, 16 samples 91 percent; 1909, 10 samples 98 percent. The seed of the 1907 market was exceptionally poor; that of 1909 relatively good. The poorer grades of the two former years were probably due more particularly to unfavorable weather conditions and consequent poor seed crops, and to the passage of the Canadian law and the consequent exportation of seed rejected in the home markets. Yet pure seed was obtainable in the two former years, inasmuch as one-third of the samples carried less than one percent impurity. In 1908, following two successive poor seed crops, the average quality improved somewhat, possibly owing to more careful selection. In 1909, following a favorable crop season, the quality was excellent and prices normal. Viewing the situation as a whole, just 20 percent of the samples were 99 percent pure or better; the fourth ranged from 95 to 99 percent pure; one-seventh from 90 to 95; one-seventh from 80 to 90; while one-sixth of the entire lot were of lower grade, three samples showing less than 70 percent purity.

The weed seed content of red clover seed, both as regards the gross amounts present and the species determined, was highly variable, one year as compared with another, one sample as compared with another. Several lots carried each almost the entire gamut of the weed seed contents of the entire 53 timothy samples. Twenty-six known kinds were discovered in the 53 timothy samples, whereas no less than 67 kinds of weed seed occurred in the 43 red clover samples, not to speak of several which were unknown, or reported simply by group name without attempt at discrimination. Eighteen of the 43 carried in excess of a dozen known varieties of weed seeds, while one showed a third of a hundred sorts and was a veritable posy garden of weeds in embryo. The following weed seeds were found most frequently and in the largest numbers:

Green foxtail or barn grass,
Yellow foxtail or pigeon grass,
The native, the red stemmed, and the English plantains.
Sheep sorrel,
White and curled docks,
Dog fennel or mayweed,
Lady's thumb or heartease,
Kale or charlock,
Lamb's quarters or pigweed,
Night flowering catchfly or sticky cockle,
Yellow trefoil or black medic,
Spiny sida,
The slender and the sprouting crab grasses,
Old witch grass,
German knot grass,
Black mustard.

The following tabular statement indicates the principal occurrence of weed seeds in red clover seed:

WEED SEEDS IN RED CLOVER SEED

Name of weed.	Number of samples in which it occurred.	Percentage of samples in which it occurred.	Maximum number per pound found in sample.	Serial number of the samples in which it occurred in largest numbers
Green foxtail	33	76	21,500	39
Ribgrass	26	60	3,600	34 & 76
Redstem plantain	25	58	3,900	40
Sheep sorrel	21	48	7,400	39
Night flowering catchfly	18	41	6,600	42
Lamb's quarters	18	41	6,400	39
Old witchgrass	16	37	2,000	95
Slender crabgrass	16	37	2,000	34
Curled dock	16	37	5,600	130
Yellow foxtail	15	34	700	126 & 130
Lady's thumb	15	34	2,000	40
Dog fennel	12	27	1,800	43
Common plantain	11	25	1,200	126
Crab grass	10	23	1,400	126
Kale	9	20	1,000	39
Yellow trefoil	8	18	2,500	42
Spiny sida	6	14	1,000	90
White dock	6	14	1,700	43
Sweet clover	3	7	5,800	11
Sprouting crabgrass	2	4	900	127
Black mustard	1	2	900	130

Only three weeds were found—the slender and the sprouting crab grases and the spiny sida—which are relatively rare in Vermont. These three doubtless have been introduced frequently enough to have become established if Vermont conditions had favored their development. The residue constitute the well known widely distributed, and often formidable pests of Vermont farms. The last column in the table above emphasizes the general weedy character of certain samples.

3. *Alsike clover.* As with the red, so with the alsike clover; wide variations in purity and in quality from year to year and as between samples. None of the 18 lots were as pure as were many of the red clovers; likewise none were as poor as were certain red clover samples; nor were there as many kinds of weed seeds found. The same general betterment obtained in the aver-

age quality in 1909 as compared with that of the two previous years and doubtless for the same reasons; 1907, 88 percent; 1908, 85 percent; 1909, 96 percent. The small number of samples analyzed makes yearly tabulation futile. The weed seeds most commonly found and in largest numbers were:

Sheep sorrel,
Yellow trefoil,
Lamb's quarters or pigweed,
Common and red stemmed plantains,
Five finger,
Night flowering catchfly,
Chickweed,
Docks,
Peppergrass,
Sedge,
Purslane,
Yellow rocket.

This list includes several occurring in but one or two samples, but which deserve special mention because of the large numbers present. Twenty-six different weeds were found in the 18 samples, exclusive of those like docks, panicums and chickweeds which could not be discriminated. The chickweeds represent at least three species (*Alsine media, A. graminia, Cerastum vulgaris*) all of which, particularly the latter, occur frequently in alsike seed. The following table shows the distribution of seeds:

WEED SEEDS IN ALSIKE CLOVER

Name of weed	Number of samples in which it was found	Percentage of samples in which it was found	Maximum number per pound in sample.	Serial number of the samples in which it occurred in largest numbers
Sheep sorrel	12	67%	10,300	12
Yellow trefoil	7	38	4,300	99
Dog fennel	6	33	1,300	53
Docks	6	33	1,600	12
Night flowering catchfly	5	27	2,700	38
Lamb's quarters	5	27	900	194
Red stem plantain	5	27	3,200	128
Common plantain	4	22	2,700	99
Five finger	4	22	1,800	128
Peppergrass	4	22	700	99
Sedge	3	17	2,700	128
Chickweeds	2	11	700	99
Red-root pigweed	2	11	2,000	128
Purslane	1	5	1,600	128
Yellow rocket	1	5	.....	140

The seeds appearing in this list are more or less common and most of them are among the most pernicious and persistent varieties. No one of the 26 kinds found could be properly termed a rare weed in Vermont. Although an important means of distributing such weeds as were already common, alsike seed does not seem as likely to do harm by the introduction of new species as is red clover.

4. *Miscellaneous seed.*

(*a*). *Red top.* Three of the 1907 samples were of average purity, 91.3 percent; two were of very good quality, the inert matter being harmless, the numbers of weed seeds small and the quality of the pure seed good. The other was of much lower grade both as regards purity and weed seed content.

Two 1909 samples showed purity percentages respectively of 92 and 77.4 percent. The pure seed was of rather poor quality and much ergotized seed was observed. Number 206 carried nearly 75,000 ergotized seed per pound, enough at three pounds per acre in seeding mixtures to place upon each square foot nearly five of the sclerotia, each capable under favorable conditions of producing thousands of spores for the infection of the crop in which they develop.

The only weed seeds not met in timothy or clover were sage brush, golden rod, and yarrow or millfoil. Yarrow, a characteristic impurity of red top seed, was freely distributed through three of the five samples. Five finger was found in two samples in large amounts, 75,000 and 25,000 per pound respectively.

(*b*). *Alfalfa.* Three samples were of fair to good quality. The nature of their seed contents was practically identical with that met with in red clover seed, the only new seed found being slender melilot, a species of sweet clover. The average purity was 97.3 percent.

(*c*). *Oats and barley.* Two samples of oats were of excellent quality and high purity. They showed but a trifling weed seed content; though of course, on account of the heavier weight of cereals than of gasses and clovers, the same number of weed seeds per pound represents a much larger number sown per acre. Only four kinds were found: kale, yelow foxtail, wild buckwheat, and chess or cheat, all more or less common weeds.

Two samples of barley were of good quality and fairly high purity, no weed seeds not hitherto mentioned being found in either sample. One showed none whatever. It would seem as if it were not impracticable to free oats and barley from such small and easily screened seeds as kale, which doubtless occur in nearly all the small grains sold in Vermont.

(*d*). *Japanese millet.* Two samples showed good quality of pure seed, but high weed seed contents (12,700 and 12,300 per pound). Such species as were discovered were already well established on Vermont soil, the only sort not hitherto mentioned in this bulletin being the large smartweed or Pennsylvania persicaria.

(*e*). *Kentucky blue grass.* But little of this seed is sold in Vermont, the reason being that it is used only for pasture and for lawns. For such purposes, however, it surpasses all other grasses. It could be used here to great advantage, particularly in seeding down pastures. As has been previously mentioned this seed is often adulterated with a Canadian species. The certain detection of its sophistication necessitates expert observation.

The only sample examined here during the three year period was not adulterated. It was secured from a reliable local seedsman, and was represented to be the best grade obtainable from a reputable wholesale house. It showed a weed seed content of two kinds, sedge and mouse ear chickweed. Poorer and adulterated grades may well have been sold and no one been the wiser.

(*f*). *Orchard grass.* One sample, representing probably the best grade sold in the state, showed a considerable quantity (14,800) of weed seeds of four kinds, velvet grass, chess or cheat, rib grass and ox-eye daisy. Velvet grass seems to be a characteristic but not a serious impurity of orchard grass seed. It occurred in this sample so freely as almost to constitute an adulteration, were it the fact, which is not the case, that velvet grass is apt to be thus used. The more common adulterant of orchard grass is either English or Italian rye grass, neither of which were found.

(*g*). *Hungarian.* A single sample was of fair quality but showed over 10,000 weed seeds per pound of eight varieties of common weeds, besides some few seeds of slender crab grass. Except for the presence of the smut fungus on some of the seeds the pure seed was of good quality.

WHENCE COME THE WEED SEEDS?

The following table discusses in condensed and tangible form the situation as to the sources of some of the weeds which infest Vermont fields. It epitomipes the several tables shown on pages 218 to 226. It is interesting to note the almost unbroken line of figures in the red clover column. But 18 of the 88 varieties of weed seeds found in this study were not discovered in red clover seed; and one of the 18 (dodder) is not uncommonly discovered therein. Forty-two species were found only in red clover seed; five only in alsike clover; one only in alfalfa; three only in red top; one only in timothy. The total number of species of weed seeds reported is 88. Doubtless many varieties of weed seeds, not discoverd in this comparatively small number of desultory examinations, have been sown during these three years upon Vermont farms.

SHOWING PERCENTAGE OF SAMPLES CONTAINING WEED SEEDS OF DIFFERENT SPECIES

COMMON NAME	BOTANICAL NAME	Timothy, %	Red clover, %	Alsike clover, %	Miscellaneous, %
Green foxtail or barn grass	(*Setaria viridis*)	4	84	11	18
Rib grass	(*Plantago lanceolata*)	4	60	16	18
Red-stem plantain	(*Plantago rugalii*)	38	58	29	12
Sheep or field sorrel	(*Rumex acetrocella*)	11	49	67	6
Night flowering catchfly or sticky cockle	(*Silene noctiflora*)	..	40	29	..
Lambs' quarters or pigweed	(*Chenopodium album*)	19	49	29	12
Old witch grass	(*Panicum capillare*)	..	40	6	6
Slender crab grass	(*Syntherisma filiforme*)	2	45	11	12
Curled dock	(*Rumex crispus*)	2	47	11	6
Yellow foxtail or pigeon grass	(*Setaria glauca*)	..	35	6	30
Lady's thumb or heartsease	(*Polygonum persicaria*)	4	33	..	6
Dog fennel or May weed	(*Anthemis cotula*)	4	28	33	12
Common plantain	(*Plantago major*)	17	23	22	6
Crab grass	(*Syntherisma sanguinalis*)	2	21	..	6
Kale or charlock	(*Brassica arvensis*)	..	21	..	12
Yellow trefoil or black medic	(*Medicago lupulina*)	..	16	33	..
Spiny sida	(*Sida spinosa*)	..	14	..	6
Docks sp.	(*Rumex sp.*)	2	30	22	6
Panicum sp.		..	11	11	..
Peppergrass	(*Lepidium virginicum, L. apetalum*)	16	23	29	12
Ragweed	(*Ambrosia artemisiaefolia*)	..	16	..	23
Five finger or cinquefoil	(*Potentilla monspeliensis*)	23	5	22	12
Spurge	(*Euphorbia nutans*)	..	19	..	6
Common pigweed	(*Amaranthus retroflexus*)	..	14	6	6
Healall	(*Prunella vulgaris*)	4	11	..	..
Yellow daisy or black-eyed Susan	(*Rudbeckia hirta*)	16	..	..	12
Sedge or swale grass	(*Carex sp.*)	11	5	17	18
Evening primrose	(*Onagra biennis*)	16	..	6	..
Chickweed	(*Alsine media*)	4	5	11	..
Spring amaranth	(*Amaranthus spinosus*)	2	5	..	..
Menzie's peppergrass	(*Lepidium menziesii*)	4	..	..	..
Canada thistle	(*Carduus arvensis*)	2	7	11	..
Blue vervain	(*Verbena hastata*)	6	5	..	..
Field dodder	(*Cuscuta arvensis*)	2	..	..	..
Hedge mustard	(*Sisymbrium officinale*)	2	2	2	..
Mullein	(*Verbascum sp.*)	2	..	..	..
Sweet clover	(*Melilotus alba*)	..	7	..	..
Goat's rue	(*Tephrosia virginiana*)	..	5	..	..
Bracted plantain	(*Plantago aristata*)	..	7	..	..
Bittersweet	(*Solanum dulcamera*)	..	5	..	..
Low amaranth	(*Amaranthus blitoides*)	..	10	..	..
Black mustard	(*Brassica nigra*)	..	2	..	..

COMMON NAME	BOTANICAL NAME	Timothy, %	Red clover, %	Alsike clover, %	Miscellaneous, %
Arrowhead tear thumb	(*Polygonum sagitattum*)	..	2	..	..
Catnip	(*Nepeta cataria*)	..	10	..	..
Smartweed	(*Polygonum hydropiper*)	..	5	..	6
Wild buckwheat	(*Polygonum convulvulus*)	..	2	..	12
Dotted smartweed	(*Polygonum punctatum*)	..	7	..	..
Quack grass or witch grass	(*Agropyron repens*)	..	2	..	..
Centaurea sp.		..	2	..	..
Three-seeded mercury	(*Acalypha virginica*)	..	5	..	..
Nettle	(*Urtica sp.*)	..	2	..	..
Sucking clover	(*Melilotus officinalis*)	..	2	..	..
Chicory	(*Cichorium intybus*)	..	2	..	6
Wild carrot	(*Daucus carota*)	..	10	..	..
German knotgrass	(*Schleranthus annuus*)	..	19	..	..
Scentless camomile	(*Matricaria inodora*)	..	2	..	..
False flax	(*Camelina sativa*)	..	2	..	..
Prairie ribroot	(*Plantago purslii*)	..	7	..	..
Slender papsalum	(*Papsalum setaceum*)	..	7	..	..
Pennyroyal	(*Hedeoma pulegioides*)	..	2	..	..
Barnyard grass	(*Echinochloa crus-galli*)	..	10	..	12
Mint	(*Mentha sp.*)	..	2	..	6
Nightshade	(*Solanum nigrum*)	..	5	..	..
Bitterdock	(*Rumex obtusifolius*)	..	2	6	..
Bladder ketmia	(*Hibiscus triomum*)	..	2	..	..
Bur clover	(*Medicago denticulata*)	..	5	..	..
Polygonum sp.		..	5	..	12
Shepard's purse	(*Bursa bursa-pastoris*)	..	2	..	..
Oxeye daisy	(*Chrysanthemum leucanthemum*)	..	2	..	6
Sprouting crabgrass	(*Panicum proliferum*)	..	5	..	..
Ground cherry	(*Physalis sp.*)	..	2	..	..
Field bindweed	(*Convulvulus arvensis*)	..	5	..	..
Bull thistle	(*Carduus lanceolatus*)	..	2	..	..
Pennycress	(*Thlaspi arvense*)	..	2	..	..
Coral berry	(*Symploricarpes orbiculatus*)	..	2	..	..
Balm	(*Melissa officinalis*)	..	..	6	..
Brome grass	(*Bromus sp.*)	..	..	6	..
Purslain	(*Portulaca oleracea*)	..	..	6	..
Yellow rocket	(*Barbarea vulgaris*)	..	..	6	..
White top	(*Danthonia spicata*)	..	..	6	..
Sage brush	(*Artemisia biennis*)	..	..	..	6
Yarrow	(*Achilles millefolium*)	..	..	..	18
Goldenrod	(*Solidago sp.*)	..	..	..	6
Slender melilot	(*Melilotus gracilis*)	..	..	..	6
Chess or cheat	(*Bromus secalinus*)	..	..	..	12
Large smartweed	(*Polygonum pennsylvanicum*)	..	..	..	6
Mouse-ear chickweed	(*Cerastrium vulgatum*)	..	..	..	6
Velvet grass	(*Holcus lannanus*)	..	..	..	6

VERMONT'S WORST WEEDS IN 1909

A circular letter was sent in the winter of 1908 to several farmers in various sections of the state asking for the names of the ten worst weeds in cultivated fields, in meadows and in permanent pastures, these to be arranged in order of the damage done. A relatively small number replied, but they were located in widely different sections. The results were combined and computed. It is interesting to compare the results of this survey with the weed seed content of the commercial seed examined during these three years. The following table indicates the worst weeds in the cultivated areas as thus reported, the statements being expressed in terms of percentages.

1.	**Quack grass (witch grass)**	**89**
2.	**Lamb's quarters (pigweed)**	**45**
3.	**Kale**	**31**
4.	**Rough pigweed**	**30**
5.	**Hedge mustard**	**35**
6.	**Sheep sorrel**	**32**
7.	**Black bindweed**	**21**
	Ragweed	**21**
8.	**Smartweed**	**17**
9.	**Green foxtail**	**16**
	Curled dock	**15**
	Canada thistle	**17**
10.	**Yellow foxtail**	**15**
11.	**Purslane**	**14**
12.	**Bitter dock**	**12**
	Barnyard grass	**12**

Every one of the 16 species designated by farmers as being Vermont's worst weeds in the cultivated areas occurs in the foregoing list of weed seeds found in grass and clover seed. Quack grass or witch grass, which leads the list, occurs less often among the grass and clover seeds than does any other one of the 16, doubtless because it matures seed very poorly and propagates almost entirely by its persistent and aggressive rhizomes or underground stems.

The worst weeds in old or permanent meadows were said to be:

1.	**Sensitive fern**	**58**
	Ox-eye daisy	**58**
2.	**Tall buttercup**	**41**
3.	**Quack grass or witch grass**	**32**
4.	**Wild carrot**	**31**
5.	**Sheep sorrel**	**27**
6.	**Goldenrods.**	**22**
7.	**Orange hawkweed (paint-brush)**	**21**
8.	**Common plantain**	**20**
9.	**Common milkweed**	**18**
10.	**Curled dock**	**15**
11.	**Canada thistle**	**14**
12.	**Wild oat grass**	**12**

Nine out of the thirteen worst weeds in meadows were represented in the grass and clover seed samples. A list of the worst pasture weeds shows only 2 out of 16 weeds whose seeds have been found in grass and clover seeds examined, these being the Canada and the bull thistles, the former appearing in the worst weed lists of both the tilled areas and the meadows.

It would appear that commercial seed is an important factor as a carrier of weeds to cultivated areas and that its relation to the weed seed content of permanent meadows is at least a measurable factor.

VERMONT'S WORST WEEDS IN 1872, 1891, AND 1898, COMPARED WITH THOSE OF 1909

A Vermont weed list, doubtless the earliest made, was submitted in 1872 by Dr. Cyrus G. Pringle, now keeper of the university herbarium. This contained 129 species, 70 of which were held to be introduced from the old country. Most of the aggressive and prolific weeds of that day were included. During the last forty years the numbers of weeds and of weed species have doubtless increased, owing to new channels of introduction, with western clover seed not the least important one. Prior to the civil war Vermont farmers raised their own clover seed. This practise had ceased, however, by the middle eighties. In 1886, Vermont grown clover seed was sold at $15 a bushel in competition with western seed at half that price. Economic considerations have forced a change in practise which has opened the door to the influx of western weeds.

The Station made surveys of the weed situation in Vermont in 1891 and 1898. Forty replies to a circular letter touching this matter were received in 1891 and about 200 in 1898. The following weeds appear in each list of the ten or a dozen worst weeds as reported in 1891, 1898, and 1909: Witch grass, white daisy, kale, orange hawkweed, plantains, wild carrot, docks. The following occur in two of the three lists: Brakes, Canada thistle, goldenrod, ragweed, sorrel. The entire twelve appear in the Pringle list of 1872.

That these weeds are pestiferous is well understood. Of more importance is the relationship of the new comers. The bulk of the weed seed contents of commercial seeds consists of well established sorts, yet such commercial seed is the natural channel for the introduction of those less well known. Only one weed is entered in the 1891 list of ten worst weeds, and but two in that of 1898 of the dozen worst weeds, which did not appear in the list previously made by Dr. Pringle, or reported in this bulletin. But among the 16 worst tillage weeds reported in 1909 appear no less than nine which are not found in the lists of 1891 and 1898; three of which moreover are not even mentioned in the long list of 28 other weeds reported in 1898 as less troublesome than the initial 12 of ill repute. Three of this year's meadow list also have not been hitherto looked upon as serious. While it is freely admitted that the present list is less representative than are the previous ones, because of the small number of farmers reporting, the proportion of species not hitherto considered to be a menace is significant. In short, it is clear that new weeds are rapidly swelling the already long list of these pests, that they are becoming prominent candidates for mention among the most troublesome invaders of meadows and tillage fields, and that the commercial seeds and feeds are their main methods of inlet.

THE NEWER WEED INVADERS

A few specific cases may be cited.

Rib grass or lance-leafed plantain was mentioned in the 1872 list as "appearing occasionally in dry fields." It was ranked sixth among the troublesome weeds in 1891, and was noted in the very complete survey of 1898 as among the ten worst weeds and as "becoming frequent in the hay fields, being introduced in clover seed." This particular seed occurred in two-thirds of the red and one-sixth of the alsike clover samples in the present survey, and in a few timothy and red top samples.

The 1872 list of 129 weeds did not mention yellow daisy or black-eyed Susan. In 1891, it stood twentieth in a list of 40 weeds reported from many sections of the state. It ranked eighth in 1898, although "doubtless reported more often that it deserved to be, owing to its conspicuousness in hay fields and its evident relationship to the old offender, the white daisy. It is a western plant introduced with western seeds." Its seeds were found in one-sixth of the timothy samples and in one red top sample in the present survey, but in none of the clover samples, although apparently sometimes found therein.

Crab grass was found in one-fourth of the red clover samples and five finger in one-fourth each of the timothy and alsike clover samples and in two out of five red tops. It appears to be introduced in grass seed. Crab grass ranked low among the long lists of 1891 and 1898, and the five finger in that of 1898.

Yellow trefoil is well understood to be an adulterant of red and alsike clover and of alfalfa seed, being imported from Europe principally for this purpose. It was found in one-fifth of the red and in two-fifths of the alsike clover samples. It has not yet been reported as a troublesome weed, being itself not objectionable in meadows and pastures, save that it usurps the place of the better clovers.

Among the weeds not found in this survey, but becoming more common and troublesome, the seeds of which are thus introduced into Vermont, may be mentioned:

Clover dodder (*Cuscuta epithymum*) first reported in Vermont in 1900; blue weed (*Echinum vulgare*); prickly lettuce (*Lactuca scariola*); hoary alyssum (*Berteroa incana*) 1895; tumble mustard (*Sisymbrium altissimum*) 1900; squirrel tail grass (*Hordeum jubatum*); wormseed mustard (*Erysinum cheiranthoides*) and (*Petstemion laevigatus*).

The first five are most to be feared. Ball mustard (*Neslia paniculata*), particularly abundant and troublesome in the mid-western and Canadian grain fields, has not as yet been introduced but is likely any day to appear in western grain and commercial seed.

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UNIVERSITY OF VERMONT
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VERMONT AGRICULTURAL

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In Cooperation with
NEW YORK AGRICULTURAL EXPERIMENT STATION
Geneva, N. Y.

The Bacterial Soft Rots of Certain Vegetables.

Brandow Printing Company,
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1910

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In Cooperation with New York Agricultural Experiment Station.

BULLETIN No. 147. THE BACTERIAL SOFT ROTS OF CERTAIN VEGETABLES.

PART I. THE MUTUAL RELATIONSHIPS OF THE CAUSAL ORGANISMS.

By H. A. HARDING and W. J. MORSE*

SUMMARY.

1. This is part of an investigation of the soft rots of cabbage, cauliflower and turnip, conducted jointly by the Agricultural Experiment Stations of New York and Vermont, and deals with the morphology and cultural characters of 43 strains of organisms.

2. These strains have been found in connection with the soft rots of a considerable number of the common fleshy vegetables and some of them have been described in literature as separate species.

3. These strains appear to be identical in morphology and a cultural study upon more than 12,000 cultures did not indicate any constant cultural differences aside from the fermentation of sugars.

4. The results from 1,500 fermentation-tube tests indicate that the entire group attacks dextrose, lactose and saccharose with the formation of acid and growth in the closed arm but that the amount of gas normally formed is so close to the amount required to saturate the liquid in the fermentation tube that the appearance of gas in the closed arm is very irregular.

5. On account of this observed variation in gas formation the organisms are arranged in six groups each with its appropriate group number. So far as it has gone this study does not show that more than one species, in the customary meaning of the term, is represented in this collection of organisms but the final word in their classification should be deferred until after a study of the pathogenicity of these cultures.

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*During his studies of this problem Prof. Morse was Assistant Botanist of the Vermont Station; he is now Plant Pathologist of the Maine Station.

INTRODUCTION.

Almost every year the attention of plant pathologists is directed toward soft rots of some of the fleshy vegetables and in the aggregate the economic losses from this class of diseases are large. In a number of such diseases the causal organism has been isolated, studied and given a specific name. These rot-producing organisms are often closely related, so closely, in fact, that in working with a freshly isolated pathogen of this class one is usually in doubt as to whether the culture under consideration is a new species or a representative of a species already described.

The attention of one of us (H) was first directed to this group in 1897, in connection with an experimental study of the black rot of cabbage, at the University of Wisconsin. The soft rot of cabbage was observed[1] in the experimental fields and cultures made. When it was found that the organism present in the rotting tissue was distinct in its chromogenesis and other cultural characteristics from *Ps. campestris,* the germ causing the black rot of cabbage, the study of the soft-rot germ was not carried further. In 1898, while studying the distribution of *Ps. campestris* in Europe, a white liquefying organism was again encountered in connection with a soft rot of various members of the turnip family. Since 1899 study of this organism has been in association with Mr. F. C. Stewart, Botanist at the New York Agricultural Experiment Station.

In 1896, Mr. Stewart made successful inoculation experiments using germs isolated from diseased cabbage on Long Island and reproduced the soft rot as it appeared in the cabbage fields. In the following year he likewise determined experimentally that a destructive soft rot of *Amorphophallus simlense* could be reproduced under proper conditions by the inoculation of a pure culture of a species of bacterium which he had isolated from diseased plants of this species. No extended study of these causal organisms was conducted at this time. Since 1900 a comparative study of the bacteria causing the soft rots of cabbage and cauliflower has been conducted at the New York Agricultural Experiment Station. A preliminary report[2] of this work was read before Section G of the American Association for the Advancement of Science at Pittsburg, Pa., June 30, 1902, and printed in *Science,* August 22, 1902.

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[1] Russell, H. L. and Harding, H. A. A bacterial rot of cabbage and allied plants. Wis. Agr. Exp. Sta. Bul. 65, p. 22. 1898.

In 1898 Professor L. R. Jones of the University of Vermont isolated an organism which produced soft rot in carrots and other vegetables and later described this organism under the name of *Bacillus carotovorus.*[3] In the summer of 1899, being convinced that the soft rot of the cabbage was a disease closely allied to carrot rot, as to cause and attendant phenomena, he started a student assistant, Mr. F. R. Pember, on the study of the cabbage rot. Mr. Pember secured three organisms resembling *B. carotovorus* and like that capable of producing a soft rot of vegetables and made comparative studies of them. In 1901 the comparative study, at the University of Vermont, of the morphology and pathogenicity of this group of rot-producing organisms was assigned to one of us (M) and over a score of pathogenic cultures were isolated from various sources. Meanwhile Professor Jones was at work upon the question of the production and activities of the toxic substances and wall-dissolving enzyms which are elaborated by these bacteria.

The fact that these similar lines of investigation were being conducted at these adjoining Stations becoming known, a conference was held between the representatives of the two Stations in July, 1902, and the work of studying the soft rots of these vegetables was divided as follows: The determination of the mutual relationships of the germs involved was assigned fo Messrs. Harding and Morse; the study of the enzyms elaborated and their relation to the host plants to

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[2] Harding, H. A. and Stewart, F. C. A bacterial soft rot of certain cruciferous plants and *Amorphophallus simlense. Science,* N. S., **16**: 314–315. 1902.

[3] Jones, L. R. *Bacillus carotovorus,* n. sp., die Ursache einer weichen Fäulnis der Möhre. *Centbl. Bakt. u. Par., II,* **7**: 12–21; 61–68. 1901. Also, Jones, L. R. A soft rot of carrot and other vegetables. Ann. Rep. Vt Agr. Exp. Station **13**: 299–332. 1901.

Mr. Jones; while the pathogenicity of the germs and the economic relations of the diseases were left to the activities of both Stations. Later, owing partly to the transfer of Mr. Morse to the Maine Station, it was decided that the work on the pathogenicity should be carried out at the New York Station. It was hoped that the three parts of this investigation might be published together, but this does not seem to be practicable. Accordingly, the present paper deals with the first two divisions, leaving the third to appear later.

The economic importance of this inquiry lies mainly in connection with the rots of carrots, cabbage, cauliflower and turnips. In order more fully to understand the relation of the organisms causing these rots it seemed desirable to include a study of a number of bacterial forms which have been known to cause similar diseases in other cultivated plants. Where these organisms are sufficiently similar as to be able in turn to attack the above vegetables their importance in connection with any rotation of crops is evident.

It is a matter of regret, in view of the close relationship which has been found between pathogens on such a wide range of plants, that the circumstances did not permit a comparative study of all the germs known to cause soft rots of plants. It is evident that such a study would yield results of great value.

The earliest isolation of this class of organisms which has come to our attention was that by Professor Pammel in 1892. His attention had been called to a destructive rot of rutabagas and yellow turnips and he states that he "carefully removed with a sterilized scalpel some of the black areas adjoining healthy tissue with a platinum needle, using the test tube of agar. Several forms of bacteria were obtained, and one of these, a bacillus producing a whitish growth on the surface of the agar, when inoculated into an apparently healthy rutabaga produced rot."[4] These fields were undoubtedly like many which have since come under our observation in that there were two distinct diseases present at the same time. Having later obtained well-marked results from inoculations with a yellow organism which he named *Bacillus campestris*, no further work was done with the white organism which, in the light of later experience, appears to have been the more important pathogen.

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[4] Pammel, L. H. Bacteriosis of rutabaga. (*Bacillus campestris*, n. sp.) Iowa Agr. College Exp. Station Bul. 27, p. 133. 1895.

Strictly speaking, the black rot of cabbage and allied plants, caused by *Bacillus*, or as it is now called, *Pseudomonas campestris*, should be included among the soft rots. While this disease ordinarily manifests itself by a drying and browning of the foliage it also often appears as a soft rot of the fleshy tissue. However, as its causal organism can be easily distinguished from the germs producing the soft rots which we have been studying, we have not included *Ps. campestris* among the organisms discussed in this paper.

As has been already suggested, the prime object of our study was to remove the present confusion which exists as to the relationships of the closely allied, white organisms which cause the soft rots of the carrot, turnip, cabbage and cauliflower.

SOURCES OF OUR CULTURES.

Professor M. C. Potter presented the results of his study of a bacterial disease of turnips to the University of Durham Philosophical Society[5] in December, 1898, in which he named the causal organism *Pseudomonas destructans*, and presented a very similar paper at the British Association[6] meeting at Dover in September, 1899. The published abstracts of these papers characterized this disease as a white rot and included a brief description of *Pseudomonas destructans*. Aside from the pathogenicity, his description in these first papers is so brief that it is very doubtful if his organism could be recognized by its aid. He characterized the organism more fully in a paper read before the Royal Society[7] in December, 1900, and translated later into German.[8] Judging from correspondence with Prof. Potter, the causal organism had been lost before the autumn of 1902. In February, 1903, he kindly furnished us, for use in this comparative study, a culture which he had freshly isolated and believed to be *Pseudomonas destructans.* However, a flagella stain showed that this was a peritrichie organism and accordingly would be classed, according to Migula, as a bacillus.

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[5] Potter, M. C. On a bacterial disease—white rot—of the turnip. From Univ. of Durham. Philo. Soc. Proc. Nov., 1899.

[6] Potter, M. C. On white rot—a bacterial disease—of the turnip. British Asso. for Adv. of Sci. Report for 1899: 921–922. 1900.

[7] Potter, M. C. On a bacterial disease of the turnip. (*Brassica Napus*). *Royal Soc. of London, Proc.* 67: 442–459, 1901. Reviewed also in *Ztschr. Pflanzenkr.*, 12: 170. 1902.

[8] Potter, M. C. Ueber eine Bakterienkrankheit der Rüben (*Brassica Napus*). *Centbl. Bakt. u. Par., II*, 7: 282–288; 353–362. 1901.

The organism which we received can hardly be looked upon as an accidental contamination since it is a typical member of the group producing soft rot in plants and is undoubtedly a true English representative of this widespread group. The failure of Prof. Potter to reisolate a Pseudomonas from decaying vegetables is not surprising in view of the fact that during the years in which we have been frequently making such isolations we have never isolated a white liquefying Pseudomonas producing this decay.

Later we obtained a culture labeled *Pseudomonas destructans* from Kral, but this was possibly derived from the same culture sent us under that name by Prof. Potter as it was likewise a bacillus.

In January, 1909, Prof. Potter kindly furnished us with a third freshly isolated culture of *Pseudomonas destructans.* The arrangement of the flagella on this was also peritrichiate and consequently it should be classed as a bacillus. In this paper the culture furnished us by Prof. Potter in 1903 will be designated as Potter's Bacillus.

Reference has already been made to the publications by Professor Jones on the soft rots of carrot and other vegetables. These publications not only included an extended description of *Bacillus carotovorus,* but also gave the results of extensive tests of its pathogenicity when inoculated into a large number of common vegetables. These results showed that, under proper conditions, soft rots of a long list of common vegetables could be produced by inoculations from a pure culture of this germ. Fortunately the original type culture of *Bacillus carotovorus* has been preserved by Professor Jones and was available for use in this comparative study.

Professor F. C. Harrison presented a paper at the Pittsburg meeting of the American Association for the Advancement of Science, entitled "A preliminary note on a new organism producing rot in cauliflower and allied plants,"[9] in which he briefly described the causal organism which he there named *Bacillus olereaceae.* In a later publication[10] he gave a very full account of the behavior of *Bacillus olereaceae* on different culture media as well as the results of inoculations of pure cultures of this bacillus into many of the common vegetables. As the result of such inoculations he reported soft rot being reproduced in cabbage, cauliflower, turnip, rutabaga, rape, radish, parsnip, carrot, mangel, sugar beet (slight), potato, celery, tomato (both ripe and green), artichoke (Jerusalem), asparagus, horse radish, rhubarb, and onions. When we applied to Professor Harrison in 1902 for a culture of *Bacillus olereaceae* he was unable to furnish it because of the loss of all of his stock, but we were so fortunate as to obtain an authentic culture from one which he had previously furnished to Dr. Erwin F. Smith.

An interesting contribution to this subject was made in 1902 by Dr. A. Spieckermann[11] of the Agricultural Experiment Station at Münster, Germany. He isolated an organism which he found to be able to reproduce a soft rot in a considerable number of the common vegetables when inoculated into them in pure culture. The cultural characteristics of this organism differed in some particulars from the ones already described by Potter and Jones, being identical, as will be shown later, with the organism afterwards found and named by Townsend.[12] However, Spieckermann did not name his organism, but in January, 1903, he kindly furnished us with a culture which will be referred to in this publication as Spieckermann's Bacillus.

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[9] Harrison, F. C. Preliminary note on a new organism producing rot in cauliflower and allied plants. *Science*, N. S., 16: 152. 1902.

[10] Harrison, F. C. A bacterial disease of cauliflower (*Brassica olereaceae*) and allied plants. Ontario Agr. College Bul. 137. 1904.

[11] Spieckermann, A. Beitrag zur Kenntniss der bakteriellen Wundfäulnis der Kulturpflanzen. *Landw. Jahrb.*, 31: 155–178. 1902.

[12] Townsend, C. O. A soft rot of the calla lily. U. S. Dept. of Agr., B. P. I., Bul. 60. 1904.

On May 21, 1902, C. J. J. van Hall presented a doctorate thesis to the University of Amsterdam, entitled "Bijdragen tot de kennis der Bakterieele Plantenziekten,"[13] in which he included an extended description of an organism producing a soft rot in the Iris family and designated by him as *Bacillus omnivorus* n. sp. Dr. van Hall later published a discussion of the pathogenicity[14] of *Bacillus omnivorus* and its manner of attack upon the iris bulbs and plants. While the soft rot of the iris was outside of the group which we originally intended to study we obtained a culture of *Bacillus omnivorus* from Kral and included it among the organisms studied.

In 1904 Dr. C. O. Townsend[15] published a description of a soft rot of calla lily including that of the causal organism which he named *Bacillus aroideae.* Through the kindness of Dr. Townsend we were given a culture of this organism at the very beginning of our work and have made a comparative study of it in connection with the germs from the other sources.

In addition to these named cultures we have made a comparative study of 37 others, isolated from various vegetables. Pember A and C were obtained from decaying cabbages by Mr. F. R. Pember in 1899. In the summer and fall of 1901 one of us (M) isolated cultures XXV, XXVI, XXIX and XXXI from decaying early cabbages from the Vermont Experiment Farm garden; cultures XLVIII, XLIX, L, LI, LII, LIV, LV and LVI from a field of late cabbages in South Burlington, Vt., and cultures XCIV, XCV, XCVI, XCVIII, C, CI, CII, CIII from cabbages in a private storage house at Burlington, Vt. In 1903, an organism, designated as Turnip Rot D, was isolated at the Vermont Agricultural Experiment Station laboratory from decaying turnips growing on the same land from which were obtained the cabbage soft rot organisms XXV-XXXI two years previously.

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[13] van Hall, C. J. J. Bijdragen tot de kennis der Bakterieele Plantenziekten. Doct. Thesis. Univ. of Amsterdam. 1902.

[14] van Hall, C. J. J. Das Faulen der jungen Schösslinge und Rhizome von *Iris florentina* und *Iris germanica*, verursacht durch *Bacillus omnivorus* v. Hall und durch einige andere Bakterienarten. *Ztschr. Pflanzenkr.*, **13:** 129-144. 1903.

[15] See footnote 12.

At the New York Agricultural Experiment Station laboratory culture 0.2 e was isolated from a decaying cauliflower from Long Island in November, 1901. Culture 0.2 f was isolated in March, 1902, from a diseased cauliflower plant in the green house. Eleven days previous this cauliflower plant had been carefully inoculated with a pure culture of 0.2 e in order to test the pathogenicity of this culture and the reisolation was made to determine the fact that the disease which had been produced was actually caused by 0.2 e. The inoculation had been made as aseptically as possible and the point of inoculation covered with melted grafting wax. The material for the reisolation was taken from the advancing edge of the diseased area and the plates indicated the presence of a pure culture in the plant tissue.

In 1902 the cultures designated as Miller and Riverhead were isolated from decaying stalks of cabbage which had been planted commercially for the purpose of raising cabbage seed. The stalks were collected as typical examples of the early stages of the destructive rot which causes a heavy loss in the cabbage seed industry on Long Island practically every year and there were two stalks from each of two fields located about 10 miles apart in the eastern portion of the island.

Cultures labeled Miller Stalk 2 No. 1 and Miller Stalk 2 No. 2 were derived from the same diseased stalk while Miller Stalk 3 No. 1, Miller Stalk 3 No. 2 and Miller Stalk 3 No. 3 were likewise isolated at the same time from another similarly diseased cabbage stalk from the same field. Riverhead Stalk 2 No. 1 and Riverhead Stalk 3 No. 1 came from two cabbage stalks out of a second field.

Cultures 0.2 RBe and 0.2 RBi were isolated in November, 1901, from a rutabaga. This was obtained from a private garden near Phelps, N. Y., and the upper portion of the rutabaga was soft and vile smelling. The cultures were prepared from blackened fibro-vascular bundles passing through the apparently sound tissue of the rutabaga. Both cultures were obtained from the same plant.

The cultures Cornell I, III and V were isolated in October, 1904, from two turnips from an experimental field at the Cornell Agricultural Experiment Station, cultures I and III being from the same turnip.

Thus this collection of cultures represents England, Holland, Germany, District of Columbia, Canada, Vermont and widely separated points in the State of New York. They were derived from turnip, iris, rape, calla lily, cauliflower and cabbage.

METHODS OF WORK.

On undertaking this comparative study in July, 1902, the first step was an exchange of cultures which had been isolated at the two Stations and a determination of their cultural characteristics. The media used in this study, with certain exceptions, were prepared in accordance with the suggestions of the report of September, 1897,[16] of the committee of the American Public Health Association on standard laboratory methods. The reaction of the media used at the New York laboratory was uniformly 1.5 per ct. normal acid to phenolphthalein while that used at the Vermont laboratory was the same during the earlier years of the study and later was made neutral to this indicator, as it was found that the organisms grew equally well, if not better, in a neutral medium. In the earlier work at the Vermont laboratory lean beef was used in preparing the media, but the resulting presence of muscle sugar in the broth led to the substitution of Liebig's meat extract. At the New York laboratory this meat extract was uniformly used except on rare occasions when beef was used as a check.

If these variations in the technique at the two laboratories had resulted in discordant results they would have been regrettable, but, as the results will show, such was not the case. On the other hand, the presence of these variations in the technique makes it all the more probable that the results here given can be duplicated in any laboratory where care is given to approximating standard conditions of work.

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[16] Report of the committee on standard methods for water analysis. *A. P. H. A. Proc.* (*1897*), **23**: 56-100. 1898.

One of the important items which should never be disregarded in comparative work of this kind is the vigor of culture. Especially when they have been long subjected to artificial conditions in a laboratory it is necessary to put the cultures through a revivifying process, a series consisting of transfers of young cultures through bouillon, gelatin and agar having been used with these germs. Comparative cultures were rarely made in duplicate but almost uniformly in triplicate. When cultures long in stock were tested without previously revivifying, discordant results from the three simultaneous cultures were occasionally obtained, while such comparisons made after the stock culture had been revivified practically always gave more accordant results.

In separating these cultures the main difference is in their ability to ferment the different sugars. Accordingly it was absolutely necessary for accurate results that the broth which was used as the basis of these tests should be free from muscle sugar. The absence of this sugar was determined by testing each lot of broth with *B coli,* and when found to be present the sugar was destroyed by the growth of this organism. By using meat extract it was found possible to prepare bouillon free from this sugar, and all of the broth used at the New York laboratory was in this way made free of muscle sugar.

METHODS OF CLASSIFICATION.

Those familiar with such work will appreciate the difficulty encountered in comparing determinations upon so many organisms scattered over a term of years and made in different laboratories. It is rare that two sub-cultures from the same original will give identical quantitative and qualitative results on a variety of media when tested side by side and when considering the large number of cultures tested at different times and places the slight variations are bewildering. Some system of classification is absolutely essential to progress. A large part of the work and delay in connection with this study was due to the absence of such a well-elaborated system.

The suggestion of Fuller & Johnson[17] that the most stable reactions of bacteria could be printed on a card and the reactions of the culture being studied could be indicated by + or —, as the facts required, was a step in the right direction. As soon as there was a collection of these cards the difficulty of their arrangement became evident and this was met in an ingenious way by Gage and Phelps.[18] They devised a group number which both recorded the more important culture reactions and provided a basis for an orderly arrangement of the cards. The value of these improvements was so evident that on this basis a committee of the Society of American Bacteriologists has worked out an official classification card. While this card is probably not in its finished form it has such marked advantages over any other method of classification which is now available that it has been utilized in presenting the results of the present study.

The Society card consists of three essential parts: (1) A group number (see page 263) along the lines originally suggested by Gage, which records the more important facts regarding an organism and at the same time provides a means of arranging the records so that duplicates can be found readily; (2) A brief characterization (see page 264) which may be filled in by means of + or —, as suggested by Fuller and Johnson, and which serves as a means of further comparing germs with the same group number; and (3) A provision for tersely recording the detailed features of cultures upon the common media as first outlined by Chester[19] (see page 284).

The basis upon which the group number is computed according to the Society card of 1907, is given in Table I.

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[17] Fuller, G. W. and Johnson, Geo. A. On the differentiation and classification of water bacteria. *Jour. Exp. Med.*, 4: 609–626. 1899. Similar article in *A. P. H. A., Proc.* 25: 580–586. 1899.

[18] Gage, S. DeM. and Phelps, E. B. On the classification and identification of bacteria with a description of the card system in use at the Lawrence Experiment Station for records of species. *A. P. H. A., Proc.* 28: 494–505. 1903.

[19] Chester, F. D. A manual of determinative bacteriology. MacMillan. 1901.

TABLE I.

A NUMERICAL SYSTEM OF RECORDING THE SALIENT CHARACTERS OF AN ORGANISM. (GROUP NUMBER.)

100.	Endospores produced
200.	Endospores not produced
10.	Aerobic (Strict)
20.	Facultative anaerobic
30.	Anaerobic (Strict)
1.	Gelatin liquefied
2.	Gelatin not liquefied
0.1	Acid and gas from dextrose
0.2	Acid without gas from dextrose
0.3	No acid from dextrose
0.4	No growth with dextrose
.01	Acid and gas from lactose
.02	Acid without gas from lactose
.03	No acid from lactose
.04	No growth with lactose
.001	Acid and gas from saccharose
.002	Acid without gas from saccharose
.003	No acid from saccharose
.004	No growth with saccharose
.0001	Nitrates reduced with evolution of gas
.0002	Nitrates not reduced
.0003	Nitrates reduced without gas formation
.00001	Fluorescent
.00002	Violet chromogens
.00003	Blue "
.00004	Green "
.00005	Yellow "
.00006	Orange "
.00007	Red "
.00008	Brown "
.00009	Pink "
.00000	Non-chromogenic
.000001	Diastasic action on potato starch, strong
.000002	Diastasic action on potato starch, feeble
.000003	Diastasic action on potato starch, absent
.0000001	Acid and gas from glycerine
.0000002	Acid without gas from glycerine
.0000003	No acid from glycerine
.0000004	No growth with glycerine

The genus, according to the system of Migula, is given its proper symbol, which precedes the number, thus:

BACILLUS COLI (Esch.) Mig.	becomes	B.	222.111102
BACILLUS ALCALIGENES Petr.	"	B.	212.333102
PSEUDOMONAS CAMPESTRIS (Pam.) Sm.	"	Ps.	211.333251
BACTERIUM SUICIDA Mig.	"	Bact.	222.232203

RESULTS OF OUR STUDY.

The results of our attempt to classify these cultures representing four named species and thirty-nine other cultures isolated from diseased vegetables are given in Table II.

TABLE II.—SHOWING THE GROUP NUMBER AND OTHER CLASSIFICATORY FEATURES OF THE GERMS STUDIED.

Group Number	NAME	MORPHOLOGY							CULTURAL FEATURES																					BIOCHEM. FEATURES									
									BROTH			AGAR				GEL. PLATE					GEL. STAB.		POTATO							LIQUEFACTION			MILK						
		Diameter over 1 μ.	Chains	Endospores	Capsule	Pseudozoogloea	Motile	Gram's stain	Turbid	Pellicle	Sediment	Shining	Dull	Wrinkled	Chromogenic	Round	Proteus-like	Rhizoid	Filamentous	Curled	Surface growth	Needle growth	Moderate	Abundant	Discolored	Starch destroyed	Grows at 37 C.	Grows in Cohn's Sol.	Grows in Uschinsky's Sol.	Gelatin	Casein	Agar	Acid curd	Rennet curd	Casein peptonized	Indol	Nitrates reduced	Fluorescent	Plant pathogen
B.221.1113022	Bacillus carotovorus	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" oleraceae	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" omnivorus	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XXV	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XXVI	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XXIX	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XXXI	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" L					+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" LI					+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" LII					+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" LV					+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XCIV	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XCV	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XCVI					+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" XCVIII	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" CI	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" CII	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" CIII	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" Pember A	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" Pember C	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" O. R B e	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+
B.221.1113022	" O. R B l	−	+	−	−	+	+	−	+	+	+	+	−	−	−	+	−	−	−	−	+	+	+	+	−	+	+	−	+	+	+	−	+	−	+	+	+	−	+

B.221.1113022	"	O. 2 f	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Cornell I	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Cornell III	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Cornell V	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Miller 2 No. 1	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	" 2 No. 2	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	" 3 No. 2	—	+	—	—	+	+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	" 3 No. 3	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Riverhead 2 No. 1	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	LVI	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1113022	"	Miller 3 No. 1	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1123022	"	X LVIII	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.1213022	"	C	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2113022	"	O. 2 e	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2113022	"	LIV	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2123022	"	Potter's	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2123022	"	Riverhead 3 No. 1	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2223022	"	XLIX	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2223022	"	Turnip Rot D	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2223022	"	Spieckermann's	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+	—	+	+	+	—	+
B.221.2223022	"	aroideae	—	+	—	—		+	—	+	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	—	+	+	+	—	+		+	+	+	—	+

The above table presents as concisely as possible the results of observations made under 38 headings. These observations were made upon an average of 25 cultures for each of the 43 germs which were studied, or an average of approximately 1,000 cultures for each heading. Owing to the fact that a single culture would furnish the information given under a number of headings, only about 12,000 cultures are actually represented in this table, although some thousand additional were required in the preliminary cultivations and in the revivifying process.

While the above results are perfectly accordant in all of the items covered by + and — it would be misleading to assume that no apparently discordant observations were made. Every item was determined a number of times, usually in triplicate, and in practically all cases these determinations were made in both laboratories, the more important of them having been determined independently by four different workers.

The importance of revivified cultures has already been emphasized and it was in the determinations which were made previous to the application of this preliminary cultivation that the larger part of the variation was encountered. However, revivication does not remove all of the tendency to vary which is resident in some of the cultures.

In summarizing in the table the results which were not entirely accordant the rule has been followed that a single well-marked positive result was more important than a number of negative ones. Wherever a single positive result was marked as doubtful for any reason and the other observations were uniformly negative the test has been recorded as negative in the table, but attention will be called to such cases in the following remarks.

Pellicle on broth. The pellicle on broth is usually thin and in many of the earlier observations it was recorded as absent. Careful observations on cultures which had not been disturbed showed that the pellicle begins with the formation of floating masses of pseudozooglea which are gradually united into a delicate film. If the culture is even gently shaken these sink and the pellicle which would have resulted is destroyed and may not be reformed.

While this delicate pellicle may be taken as characteristic for the entire collection of cultures, six members of the B. 221.1113022 group—*B. olereaceae,* CI, 0.2 f, Miller Stalk 3 No. 3, Riverhead Stalk 2 No. 1 and Miller Stalk 3 No. 1—have from time to time shown a pellicle somewhat stronger than the rest, which tends to hold together when shaken. The reasons for this variation have not been more closely determined.

Agar colonies. Townsend in his description of *B. aroideae*[20] laid some stress on the diagnostic value of radiating surface colonies which appeared on lightly seeded agar plates that had been inoculated from fresh cultures and been held at 22° to 35° C. Early in the work some attention was given to this point, particularly at the Vermont laboratory. It was found that on lightly seeded plates these radiating, amoeboid-shaped colonies were usually produced by *B. aroideae,* Spieckermann's Bacillus and Turnip Rot D, lending color to the idea that the absence of gas formation was in some manner correlated with a tendency to the formation of these colonies. However, the formation of these colonies was not restricted to these organisms and on at least one occasion they were formed by 0.2 f, Vermont XLVIII and Turnip Rot D when they were not formed by *B. aroideae* nor Spieckermann's Bacillus, although all five were tested together under parallel conditions of media, temperature and dilution.

At the New York laboratory no systematic study was made of this point partly because the work at the Vermont laboratory indicated that it had no diagnostic value and largely because variations in moisture and temperature effect such marked changes in the colony growths of practically all bacteria. The occasional formation of radiating colonies was observed in connection with a considerable number of the forms, but no determination was made of the exact conditions under which they were produced.

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[20] Townsend, C. O. A soft rot of the calla lily. U. S. Dept. of Agr. B P. I., Bul. 60, pp. 17 and 39. 1904.

Potato discolored. The difficulty with this determination lay not so much in a variation in the cultures as in the different conceptions which various workers had of the meaning of the term. As used in the table it refers to the formation of the nearly white halo which is seen around the margin of the growth with certain species of bacteria. This was not observed with this collection of cultures. On the contrary, the portion of the potato not covered with the luxuriant glistening, creamy growth was ordinarily darkened to a faint brownish gray, the extent of this change varying apparently with the characteristics of the potato itself.

Potato starch destroyed. This item has been added to the classification card recently and the determinations were made at the New York laboratory only. The test was made on sterilized potato cylinders in test tubes upon which cultures were grown for two weeks. These potato cultures were crushed in porcelain mortars and 50 cc. of water added to separate the particles so that the effect of the iodine could be easily seen. The presence of unchanged starch was determined by the gradual addition of a weak solution of iodine in potassium iodide. After a sufficient amount has been added to satisfy some of the other compounds which are present the starch grains are turned to a blue-black. The extent of the reduction of the starch by the bacterial growth is estimated on the basis of similar tests of uninoculated potato cylinders. In none of these cultures was the starch reduction complete, but amylodextrin was formed. (See page 331.) This change was expressed by 2 in the appropriate place in the group number.

For the details of this method of determining this action on the starch, we are indebted to Dr. Erwin F. Smith who assisted us by correspondence and by a demonstration in connection with the meeting of the Society of American Bacteriologists at Baltimore.

Uschinsky's Solution. The advantage of this solution lies in the definite chemical compounds used in its preparation, but unfortunately the variation in the results obtained from its use is wider than in a majority of the media ordinarily employed. Jones and Townsend found this medium well suited to the forms which they studied earlier, but the use of this medium in the later study at the Vermont laboratory did not result in any visible growth. A test of the entire collection of cultures at the New York laboratory in 1909 likewise failed to produce growth in any case. A study of the commercially pure chemicals which had been obtained from one of the most responsible houses revealed the fact that the compound supposed to be di-basic potassium phosphate was really the mono-basic salt. This produced a marked acidity in the medium and probably inhibited the growth. A redetermination with chemicals which were true to name gave an abundant growth in all cases.

Gelatin liquefaction. All of the cultures in this collection produced an evident liquefaction in gelatin stab in all of the many tests except in the case of one series of cultures made at the New York laboratory in 1905, when the entire collection either liquefied very slowly or entirely failed to do so. Shortly before this date some attention was being given in Europe to the suggestion of van't Hoff[21] of the addition of formalin to gelatin to raise its melting point. The gelatin used in the above tests was of the "Gold Label" quality and had been imported through the regular channels. A discussion of this difficulty in the matter of liquefaction before the Society of American Bacteriologists at their Philadelphia meeting brought out the fact that a number of other workers had had similar experiences. With the substitution of a new supply of gelatin all of the soft-rot cultures again produced liquefaction.

While all of these cultures produced an evident liquefaction of gelatin the rate at which this result was produced varied widely both among the different cultures tested at the same time and among the different tests of a single culture. The cultures known as Cornell I and Cornell V were isolated on practically the same date from diseased turnips in the same field and the qualitative record of these cultures in the above table is identical in all particulars. They were as similar as two subcultures from a single source would be expected to be except in the matter of liquefaction. In parallel cultures made in triplicate at the same time, on gelatin stabs from the same flask of gelatin, from agar slopes treated as nearly alike as possible Cornell I produced large dry pits while Cornell V liquefied practically the entire stabs in three weeks. Again in his description of *B. aroideae,* Townsend called attention to the rapidity of its action, completing the liquefaction in 3—5 days. In our studies the culture which he furnished us varied relatively from one of the more rapid to one of the slowest in the collection. The rate and form of liquefaction appears to vary with what may be termed the general vigor of the culture and more especially with regard to the relation of the culture to oxygen. Unfortunately our knowledge of the factors which influence the cultures in these particulars is extremely fragmentary.

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[21] van't Hoff, H. J. Erhöhung des Schmelzpunktes der Nährgelatin mittels Formalin. *Centbl. Bakt. u. Par.*, *I*, **30**: 368. 1901.

Milk—Acid curd. The distinction between acid and rennet curds is of historical rather than practical value in the study of many bacterial forms. In this group the distinction cannot be made with certainty and different observers have varied accordingly. The formation of the curd is probably due to the joint action of an enzym and of acid. The record was made of acid curd + because there is an evident acid formation preceding the curdling.

Casein peptonized. Here again the various observers differed markedly in their conclusions because the visible digestion of the curd is so slight that it cannot with certainty be differentiated from the shrinking which would result from the action of the acid on the curd. The action of the various cultures on milk was alike and the final record of + was based on the results of milk agar plates prepared after the suggestion of Hastings[22] where the ability of the organisms to attack the casein seems to be clearly brought out.

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[22] Hastings, E. G. Milchagar als Medium zur Demonstration der Erzeugung proteolytischer Enzyme. *Centbl. Bakt. u. Par., II,* **10**: 384. 1902.

Indol. The production of indol by this collection of cultures is slight in all cases and the various observers have not always considered that the red color produced by the test was sufficient to be considered positive. However in both laboratories series of tests have been considered as sufficiently decided to be classed as positive. It will be noted that this result is not in accord with the record of Townsend[28] with *B. aroideae,* but the disagreement is undoubtedly a matter of interpretation of results rather than a difference in organisms.

Nitrate reduction. It was only in a few instances that the reduction of nitrates was not detected in the standard solutions. In all of these instances succeeding cultures showed the characteristic color reaction. The cultures which failed had not been revivified previous to the test.

Gas formation. As has already been indicated the gas formation from dextrose, lactose and saccharose in the fermentation tube offers a basis for classifying this collection of cultures. Owing to the importance of the observation on this point and to the somewhat conflicting results obtained with some of the cultures, the results of the various determinations are here given in Table III.

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[28] Townsend, C. O. loc. cit. p. 32.

TABLE III.—BEHAVIOR OF SOFT ROT BACTERIA IN FERMENTATION TUBES.

Date	Laboratory	Observer	Germ	Group No.	Revivified	Dextrose		Lactose		Saccharose	
						Gas	Per ct.	Gas	Per ct.	Gas	Per ct.
1903	......	......	B. omnivorus	......	......	....	....	....	....	....	....
1903	N	P	"	.111	—	+	....	+	....	+	....
1903	V	M	"	.111	—	+	8	+	15	+	6
1904	V	M	"	.1	+	+	2	....	....	....	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.1	+	+	15	....	....	....	....
1903	......	......	XXV	......	......	....	....	....	....	....	....
1903	N	P	"	.111	—	+	....	+	....	+	....
1903	V	M	"	.111	—	+	8	+	7	+	3
1903	V	S	"	.111	—	+	5	+	12	±	10
1903	V	S	"	. 1	—	....	....	....	....	+	6
1904	V	M	"	.1	+	+	....	....	....	....	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.1	+	+	10	....	....	....	....
1905	V	S	"	.1	+	+	....	....	....	....	....
1903	N	P	XXVI	.111	—	+	....	+	....	+	....
1903	V	M	"	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	XXIX	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	XXXI	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	12	+	18	+	8
1903	N	P	L	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	LI	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	LII	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	LV	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	N	P	XCVI	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1903	V	M	Pember C	.111	—	+	18	+	7	+	30
1903	V	S	"	. 1	—	....	....	±	8	....	....
1903	V	S	"	.111	—	+	13	±	2	+	14
1903	N	P	"	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1904	V	M	"	.1	+	+	20	....	....	....	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	N	P	Cornell I	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	5	+	12	+	5
1905	N	P	Cornell III	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	....	+	15	+	4
1905	N	P	Cornell V	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	5	+	15	+	5
1903	N	P	Miller 2 No. 1	.111	—	+	....	+	....	+	....
1904	N	P	"	.111	—	+	....	+	....	+	....

TABLE III.—BEHAVIOR OF SOFT ROT BACTERIA IN FERMENTATION TUBES.

Date	Laboratory	Observer	Germ	Group No.	Revivified	Dextrose		Lactose		Saccharose	
						Gas	Per ct.	Gas	Per ct	Gas	Per ct.
1903	N	P	Miller 2 No. 2	.111	—	+	....	+	....	+	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.111	+	+	10	+	10	+	10
1905	N	P	“	.111	+	+	....	+	....	+	....
1902	V	M	B. carotovorus	.111	—	+	....	+	....	+	....
1903	N	P	“	.111	—	+	....	+	....	+	....
1903	V	M	“	.111	—	+	....	+	....	+	....
1903	V	M	“	. 11	—	....	....	+	....	+	....
1904	N	P	“	.212	—	—	....	+	....	—	....
1905	N	P	“	.111	+	+	....	+	....	+	....
1905	V	S	“	.1	+	+	....	....	....	....	....
1903	N	P	B. olereaceae	.112	—	+	....	+	....	—	....
1903	V	M	“	.111	—	+	4	+	10	+	3
1904	N	P	“	.112	—	+	....	+	....	—	....
1904	N	H	“	.211	—	—	....	+	....	+	....
1904	V	M	“	.1	+	±	1	....	....	....	....
1905	V	S	“	.1	+	+	10	....	....	....	....
1905	N	P	“	.111	+	+	....	+	....	+	....
1904	V	M	O. RBe	.2	—	—	....	....	....	....	....
1905	V	S	“	.1	—	±	5	....	....	....	....
1905	V	S	“	.111	+	±	1	+	5	+	....
1905	N	P	“	.111	+	+	....	+	....	+	....
1903	N	P	O. RBi	.111	—	+	....	+	....	+	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.111	+	+	10	+	12	+	5
1905	N	P	“	.111	+	+	....	+	....	+	....
1903	N	P	Riverhead 2 No. 1	.111	—	+	....	+	....	+	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1904	N	H	“	.211	—	—	....	+	....	+	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.111	+	+	8	+	12	+	10
1905	N	P	“	.111	+	+	....	+	....	+	....
1903	N	P	CI	.111	—	+	....	+	....	+	....
1904	V	M	“	.1	+	±	1	....	....	....	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1905	N	P	“	.111	+	+	....	+	....	+	....
1905	V	S	“	.1	+	±	10	....	....	....	....
1905	V	S	“	.112	+	±	1	+	12	—	....
1903	N	P	XCV	.111	—	+	....	+	....	+	....
1903	V	S	“	.212	—	—	....	+	8	—	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1902	V	M	Pember A	.111	—	+	4	+	8	+	10
1903	V	M	“	.111	—	+	10	+	10	+	16
1903	N	P	“	.112	—	+	....	+	....	—	....
1903	V	M	“	. 1	—	....	....	....	....	±	8
1903	V	S	“	.1	—	±	3	....	....	....	....
1903	V	S	“	.111	—	±	6	+	10	±	4
1904	N	P	“	.112	—	+	....	+	....	—	....
1905	N	P	“	.111	+	+	....	+	....	+	....
1905	V	S	“	.1	+	+	18	....	....	....	....
1903	N	P	LVI	.112	—	+	....	+	....	—	....
1904	N	P	“	.121	—	+	....	—	....	+	....
1902	N	H	0.2 f	.21	—	—	....	+	10	....	....
1904	N	P	“	.111	—	+	....	+	....	+	....
1904	N	H	“	.211	—	—	....	+	....	+	....
1904	V	M	“	.2	+	—	....	....	....	....	....

TABLE III.—BEHAVIOR OF SOFT ROT BACTERIA IN FERMENTATION TUBES.

Date	Laboratory	Observer	Germ	Group No.	Revivified	Dextrose		Lactose		Saccharose	
						Gas	Per ct.	Gas	Per ct.	Gas	Per ct.
1905	V	S	0·2 f	.111	+	+	10	+	10	+	5
1905	N	P	"	.111	+	+	....	+	....	+	....
1906	N	P	"	.1	+	±	....	....	....	....	....
1906	N	P	"	.222	+	—	....	—	....	—	....
1903	N	P	CII	.222	—	—	....	—	....	—	....
1904	N	P	"	.222	—	—	....	—	....	—	....
1904	V	M	"	.1	—	+	1	....	....	....	....
1905	V	S	"	.1	+	+	10	....	....	....	....
1905	V	S	"	.111	+	±	1	+	12	+	4
1905	N	P	"	.111	+	+	....	+	....	+	....
1903	N	P	CIII	.212	—	—	....	+	....	—	....
1903	V	M	"	.212	—	—	....	+	8	—	....
1903	V	M	"	.1	—	....	....	+	5	....	....
1904	V	M	"	.1	+	+	1	....	....	....	....
1904	N	P	"	.212	—	—	....	+	....	—	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.2	+	—	....	....	....	....	....
1905	V	S	"	.111	+	±	1	+	12	±	5
1903	N	P	XCVIII	.111	—	+	....	+	....	+	....
1903	V	M	"	.222	—	—	....	—	....	—	....
1903	V	S	"	.212	—	—	....	±	8	—	....
1903	V	S	"	.1	—	....	....	+	5	....	....
1904	V	M	"	.1	+	+	1	....	....	....	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	10	+	10	+	5
1903	N	P	XCIV	.211	—	—	....	+	....	+	....
1903	V	M	"	.222	—	—	....	—	....	—	....
1903	V	S	"	.212	—	—	....	+	8	—	....
1903	V	S	"	.1	—	....	....	+	8	....	....
1904	V	M	"	.1	+	+	1	....	....	....	....
1904	N	P	"	.111	—	+	....	+	....	+	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	+	8	+	10	+	5
1903	N	P	Miller 3 No. 3	.222	—	—	....	—	....	—	....
1904	N	P	"	.222	—	—	....	—	....	—	....
1904	V	M	"	.2	+	—	....	....	....	....	....
1905	V	S	"	.111	+	+	1	+	8	+	1
1905	N	P	"	.111	+	+	....	+	....	+	....
1903	N	P	Miller 3 No. 2	.222	—	—	....	—	....	—	....
1903	V	M	"	.212	—	—	....	+	5	—	....
1904	V	M	"	.2	+	—	....	....	....	....	....
1904	N	P	"	.222	—	—	....	—	....	—	....
1905	N	P	"	.111	+	+	....	+	....	+	....
1905	V	S	"	.111	+	±	5	+	4	+	1
1905	V	S	"	.2	+	—	....	....	....	....	....
1903	N	P	Miller 3 No. 1	.222	—	—	....	—	....	—	....
1904	N	P	"	.222	—	—	....	—	....	—	....
1904	V	M	"	.2	+	—	....	....	....	....	....
1905	V	S	"	.2	+	—	....	....	....	....	....
1905	V	S	"	.1	+	±	1	....	....	....	....
1905	V	S	"	.112	+	±	1	+	5	—	....
1905	N	P	"	.211	+	—	....	+	....	+	....
1905	N	P	"	.2	+	—	....	....	....	....	....
1906	N	P	"	.22	+	—	....	—	....	....	....
1906	N	P	"	.111	+	+	....	±	....	±	....
1902	V	M	XLVIII	.212	—	—	....	+	8	—	....
1903	N	P	"	.112	—	+	....	+	....	—	....
1903	V	M	"	.222	—	—	....	—	....	—	....
1903	V	M	"	.1	—	....	....	+	2	....	....

TABLE III.—BEHAVIOR OF SOFT ROT BACTERIA IN FERMENTATION TUBES.

Date	Laboratory	Observer	Germ	Group No.	Revivified	Dextrose		Lactose		Saccharose	
						Gas	*Per ct.*	Gas	*Per ct.*	Gas	*Per ct.*
1903	V	M	XLVIII, cont'd......	.212	—	—	....	+	9	—	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1904	N	P	“	.112	—	+	....	+	....	—	....
1905	N	P	“	.212	+	—	....	+	....	—	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.112	+	±	1	+	12	—	....
1905	N	P	“	.2	+	—	....	....	....	....	....
1906	N	P	“	.21	+	—	....	+	....	....	....
1906	N	P	“	.212	+	—	....	±	....	—	....
1903	N	P	C....................	.121	—	+	....	—	....	+	....
1904	N	P	“	.121	—	+	....	—	....	+	....
1903	.N.	P	LIV...............	.211	—	—	....	+	....	+	....
1904	N	P	“	.211	—	—	....	+	....	+	....
1902	N	H	0.2 e...............	.21	—	—	....	+	10	....	....
1903	V	M	“	.212	—	—	....	±	1	—	....
1903	V	M	“	.211	—	—	....	+	6	+	4
1904	V	M	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.211	+	—	....	+	10	±	2
1905	N	P	“	.211	+	—	....	+	....	+	....
1905	N	P	“	.2	+	—	....	....	....	....	....
1906	N	P	“	.11	+	±	....	+	....	....	....
1906	N	P	“	.1	+	±	....	....	....	....	....
1906	N	P	“	.211	+	—	....	+	....	±	....
1903	V	M	Potter's Bacillus....	.212	—	—	....	+	4	—	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.21	+	—	....	+	10	....	....
1905	N	P	“	.212	+	—	....	+	....	—	....
1905	N	P	“	.2	+	—	....	....	....	....	....
1906	N	P	“	.21	+	—	....	+	....	....	....
1906	N	P	“	.212	+	—	....	±	....	—	....
1903	N	P	Riverhead 3 No. 1...	.212	—	—	....	+	....	—	....
1904	N	P	“ ...	.212	—	—	....	+	....	—	....
1904	N	H	“ ...	.222	+	—	....	—	....	—	....
1904	V	M	“ ...	.2	+	—	....	....	....	....	....
1905	V	S	“ ...	.2	+	—	....	....	....	....	....
1905	V	S	“ ...	.222	+	—	....	—	....	—	....
1905	N	P	“ ...	.222	+	—	....	—	....	—	....
1903	V	S	B. aroideae..........	.222	—	—	....	—	....	—	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	N	P	“	.222	+	—	....	—	....	—	....
1905	N	P	“	.2	+	—	....	....	....	....	....
1906	N	P	“	.22	+	—	....	—	....	....	....
1903	V	S	Spieckermann Bacillus.	.222	—	—	....	—	....	—	....
1905	V	S		.2	+	—	....	....	....	....	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	N	P	“	.222	+	—	....	—	....	—	....
1905	N	P	“	.2	+	—	....	....	....	....	....
1903	N	P	XLIX...............	.222	—	—	....	—	....	—	....
1904	N	P	“	.222	—	—	....	—	....	—	....
1903	N	P	Turnip Rot D	.222	—	—	....	—	....	—	....
1903	V	S	“	.222	—	—	....	—	....	—	....
1904	V	M	“	.2	+	—	....	....	....	....	....
1904	N	P	“	.222	—	—	....	—	....	—	....
1904	N	H	“	.222	+	—	....	—	....	—	....
1905	N	P	“	.222	+	—	....	—	....	—	....
1905	V	S	“	.2	+	—	....	....	....	....	....
1905	V	S	“	.2	+	—	....	....	....	....	....

It will be seen from this table that the determinations of fermentative ability extended from 1902 to 1906, but that the larger amount of work on this phase of the subject was done in 1904 and 1905. Under laboratories, V and N refer to the Vermont and New York laboratories respectively. Under observers, M and H refer to the authors while S and P indicate that the actual manipulations of the determinations were done by L. P. Sprague or M. J. Prucha, assistants at the two laboratories. These tests were made under the immediate supervision of the authors, and the results were, for the most part, personally inspected by them, and they accept the responsibility for their accuracy.

Under group number is given the group number which would result from the particular determinations in question and an inspection of this heading under each organism brings out sharply the variations observed.

It should be remembered that each of the 550 determinations of fermentative ability recorded in the above table was conducted almost exclusively in triplicate, a comparatively small number having been made in duplicate so that this table really summarizes the results from approximately 1,500 fermentation tube cultures. It occasionally happens that in a fermentation test in triplicate, gas will not appear in one or more of the tubes and this is especially liable to happen where the total amount of gas is small, as in the case of this group of organisms. A complete record of these discordant results was kept at the Vermont laboratory and the cases are indicated in the table by ±. The total number of these cases observed at the Vermont laboratory was 23. At the New York laboratory where the card system of note keeping was being tried in various forms the record on the card was made on the basis of the triplicate test rather than that of the individual fermentation tube and the exact number of these variations is not known, but they were probably not greater than those given for the Vermont laboratory.

In the fermentation tubes which were used the closed arm has a capacity of 10 cc. In all but a few cases the gas produced had a volume of 1 cc. or less and accordingly was recorded as 10 per ct. or less. Owing to the rounded form of the upper end of the fermentation tube it is difficult to estimate quantities under 10 per ct. with any considerable accuracy. Since practically all of the determinations were under this amount an accurate measurement was not attempted at the New York laboratory, but fortunately this was practically always done at the Vermont laboratory and the resulting measurements are given in the table.

A striking fact brought out by this table is the frequent failure to form gas which occurred in fermentation tests made with the same organism at different times. So marked was this tendency to vary that contradictory results were obtained with 21 of the 43 strains which were studied. This number would undoubtedly have been even larger if all of the strains had received an equal amount of study. Those with which the action on each of the sugars was tested on but two occasions make up 13 of the 22 strains among which variations were not noted. Taking the results as they stand there were 91 out of a total of 550 tests which did not show gas where it was found at other tests. Accordingly, when making a fermentation test in triplicate with one of these cultures the chances were over 16 per ct. that the conclusion reached was diametrically opposed to the truth, provided we accept the contention that a positive result is of more value than a negative result in fermentation test, proper care being used to prevent outside contamination and to provide uniform conditions. If this chance of error is considered as restricted to the strains with which variation was actually observed the above record does not express the actual gas-forming ability of the organism in 91 out of 347 observations, or 26 per ct.

The influence of the revivifying process on the certainty of a correct result is shown by comparing the error noted when this preliminary treatment was given with the error when it was omitted. Where the cultures had not been previously revivified, but inoculations were made into the fermentation tubes from young, actively-growing agar slopes, there was an error in 63 out of 189 observations, or 33 per ct. Where the cultures were given a preliminary cultivation as already explained (page 261), there were 28 errors out of 158 trials, or 18 per ct. This decrease of 15 per ct., or practically one-half, in the inaccuracy of the test brings out clearly the importance of revivifying cultures before attempting to determine their fermentative ability.

Again it will be noted that the failure to form gas during a part of the tests is not equally distributed among the three sugars, but that there are 47 cases with dextrose, 17 with lactose and 27 with saccharose. While it is true that a few more tests were made with dextrose than with either of the other sugars, this increase is not at all proportional to the larger number of failures.

In arranging Table III the organisms which had always formed gas from all of the sugars at all of the trials were placed first, followed by those in which failures to form gas had been noted. These latter were arranged in the order of the frequency of this failure down to Miller Stalk 3 No. 1 which, while it formed gas from each of the sugars during some of the tests, failed to do so in 13 out of 21 instances.

The fermentative vigor of these cultures was fairly proportional to this arrangement. The fairly distinct amounts of gas formed by the first cultures in the table gradually diminishes down the table until there is rarely more than a small bubble with dextrose in the case of CII, CIII, XCVIII, XCIV and Miller Stalk 3 Nos. 1, 2 and 3. The amounts of gas formed from saccharose also undergoes a like shading down, but its formation in appreciable quantities continues beyond the point where the formation of gas from dextrose ceases. Beginning with Potter's Bacillus there is a group which does not form visible gas from either dextrose or saccharose, but is able to form it from lactose. The remaining cultures in this table have never produced visible gas in the fermentation tubes in any of the determinations which have been made.

Riverhead Stalk 3 No. 1 is a significant member of the group connecting this last group with the one preceding it since in the earlier studies of this organism it fermented lactose with evident gas formation, but in all of the later studies it failed to produce gas even after having been revivified. Although this germ apparently lost its ability to produce gas after the beginning of this study it should not be concluded that this was the rule, as it was really an exception. Owing to the stimulating effects of revivification which was practiced only during the latter part of the study a very considerable number of germs formed gas during the later tests when they had not done so during the earlier ones.

The fermentation tube has been largely used in the past to differentiate closely related species. It might be concluded in the light of the contradictory results which have been obtained in this study that the fermentation test is really of little value for this purpose. Such a general conclusion does not logically follow from this data because the particular group of organisms which have been studied here chance to lie on the very border line of visible gas formation and accordingly are not typical of germ life in general.

The fact that this group does lie on the border line of visible gas formation is shown by the fact that the amount of gas is small in most cases, in some cases only a small bubble appearing in the fermentation tube, and also by the failure of even this small amount of gas to appear in a considerable proportion of the tests with some of the strains.

The crudeness of the fermentation tube as a measure of the total gas formation is well brought out by Keyes.[24] He found in his study of *B. coli* that the total gas produced under comparable conditions in the fermentation tube and in a vacuum were in the ratio of 12.4 to 99.9.

In considering the importance which should be attached to the results obtained with the fermentation tube it should be remembered that all forms of living protoplasm respire gases and with the bacteria the carbon dioxide of respiration is an easily measurable quantity even with those forms which show no evidence of gas formation in the fermentation tube. The failure of the gas to appear in the tube is due to its solution in the liquid media and partial diffusion through the open arm of the tube. The ability of the liquid to hold appreciable amount of gas in solution is illustrated by the bubbles of gas which appear in the top of the tube after the medium has been heated in the sterilizing process and again disappear on cooling.

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[24] Keyes, F. G. The gas production of *Bacillus coli*. *Jour. Med. Research*, N. S., 16: 69–82. 1909.

While exact measurements are lacking it is probable that the gas of respiration does not nearly saturate the fluid in the fermentation tube so that the appearance of gas in the closed arm does not mark the beginning of the true fermentative action but rather a somewhat advanced stage of this action. Conversely, when dealing with a group of cultures which are on the turning point of the formation of visible gas, the failure of the gas to appear does not necessarily mean that the ability to ferment the sugar in question has been lost but rather that it has been so diminished as not to supersaturate the fluid in the tube. The fact of the continuation of the growth in the closed arm and of the formation of acid in these fermentation tube cultures lends color to the idea that the sugar is still being attacked in the same general way though less vigorously than before.

CLASSIFICATION.

Classification in a case like this may serve either of two distinct ends. It may assist future students to recognize the relationships of cultures which they may study and it may be of service to the farmer in showing whether the form which is present on a given crop will be dangerous to a succeeding crop which he may desire to grow later on the same soil. Because of the limited knowledge of germ life which is now available, any classification of such forms must be considered as tentative and as merely expressing the judgment of the authors concerning the relationships under discussion. In this connection it should be stated that some of the doubtful points in this classification were referred to six of our friends whose judgment was considered as of especial value in such matters. There was such a wide variation in what they considered the proper course to follow that it has seemed best to confine the present publication largely to a presentation of the facts as observed and leave at least the more complicated portion of the classification until after the discussion of the pathology of these cultures.

It was brought out in Table II that these 43 cultures are practically identical with regard to the 38 headings under which they were there compared and that the only observed differences were those of fermentative ability which were clearly expressed by the group numbers.

It is seen from Table III that the first 15 cultures there given are identical in their fermentative ability in that all of them produce visible gas in the fermentation tube from dextrose, lactose and saccharose. If the principle is accepted that a single well demonstrated, positive result is conclusive the 18 additional cultures down to and including Miller Stalk 3 No. 1 must be held to be identical with the first 15.

Of this group of 33 cultures having the group number B. 221.1113022, *Bacillus carotovorus* Jones is the oldest described species and should be taken as the true representative of this collection of cultures. The two other cultures which have been described in literature as bacterial species, *Bacillus omnivorus* van Hall and *Bacillus olereaceae* Harrison, are clearly identical with *Bacillus carotovorus* and there is no further occasion for continuing to recognize them as distinct species.

Continuing the arrangement of the cultures on the basis of the results from the fermentation tube the next group would have the group number B. 221.1123022 and is represented by the single strain Vermont XLVIII. This culture ferments dextrose and lactose with visible gas formation, but no apparent gas is formed from saccharose.

Mathematically the next group has the group number B. 221.1213022 and is likewise represented by a single strain, Vermont C. This group is characterized by the failure to form visible gas from lactose.

The next possibility is the failure to form gas from dextrose while forming it from the other two sugars under consideration and this group with a group number of B. 221.2113022 is represented by Vermont LIV and 0.2e. The faintness of the boundaries between these groups is shown by the case of 0.2e where in two determinations gas was actually formed in a single fermentation tube in each case. This result has not been accepted as conclusive because in neither case were the results from the accompanying tubes accordant.

The next group bears the group number B. 221.2123022 and is represented by Potter's Bacillus and Riverhead Stalk 3 No. 1. The former is a good illustration of the group while the latter forms a connecting link with the following group, since while it formed visible gas from lactose in the earlier tests it failed to do so during the latter studies and but for the earlier determinations would be included in the following group.

The series of groups is closed with a group of four cultures in which there was no visible gas formed from any of the sugars at any of the tests. This has a group number of B. 221.2223022 and *Bacillus aroideae* Townsend, is the only named species. Spieckermann's Bacillus was isolated and described at an earlier date, but was not given a specific name.

Summarizing this arrangement on the basis of the results from the fermentation tube test with dextrose, lactose and saccharose we have the following:

B. 221.1113022	*Bacillus carotovorus* Jones and 32 other cultures.
B. 221.1123022	Vermont XLVIII.
B. 221.1213022	Vermont C.
B. 221.2113022	Vermont LIV and 1 other culture.
B. 221.2123022	Potter's Bacillus and 1 other culture.
B. 221.2223022	*Bacillus aroideae* and 3 other cultures.

It will be observed that the two possible groups of .221 and .122 are not represented. It is really surprising that in a collection of 43 cultures there should have been examples of six different groups and there is no apparent reason why a study of a larger number of cultures should not bring out these missing ones.

The above arrangement is one which will appeal to the students of this field because it clearly summarizes the observed results and provides a type for all of the cultures which will be found except those which belong to the missing groups above referred to. Unfortunately this clearness of classification is more apparent than real, since practically each successive determination of the collection of cultures led to a rearrangement of the representatives of the various groups with a gradual shifting toward the upper groups because of the greater importance placed on a positive result than on a negative one. The final accumulation of 33 cultures in the upper group is largely the expression of the continued action of the law of chance and had the study continued longer this group would undoubtedly have been correspondingly enlarged.

An inspection of Table III shows that while some of the organism gave constant results at the various determinations a considerable number vibrated from one end of the above set of group numbers to the other at different determinations, often being classed temporarily with a number of the intermediate groups. Under such circumstances the above classification is seen to represent divisions which are too shifting and transient to be designated as species.

While the authors do not desire to be dogmatic in this connection the conception has been forced upon them during this study extending over a series of years that they were dealing with a group of organisms which were very closely related and which combined a remarkable stability and uniformity with regard to practically all of their culture characteristics with a remarkable variability with regard to the results from the fermentation tube test with certain sugars. It would seem that the correct explanation of this apparent variability was the fact that the entire group had a very weak fermentative ability and the gas formed from the sugars in question was approximately equal to the amount required to saturate the fluid in the fermentation tube and provide for the diffusion which is unavoidable in that test. With the changes in the fermentative vigor of the culture, concerning the details of which comparatively little is known, the amount of gas produced fluctuates above and below this saturation point giving the accompanying positive and negative results based on the presence or absence of visible gas in the closed arm of the fermentation tube.

The important fact of this fluctuation having been recognized it is a matter of little consequence to the scientist whether it is maintained that there are six species or only one. It should be mentioned in passing that the idea of species as originally conceived is entirely inapplicable to bacteria since it was based on morphological similarity coupled with an ability to produce fertile offspring. Morphologically the entire bacterial world can be divided into only a few groups and sexual reproduction is entirely lacking. In the present instance it seems to the authors that the only possible basis for recognizing more than one so-called species in connection with the present group of cultures must lie in the relation of the parasite to the host and since that part of the subject will be treated in a succeeding publication the matter of classification will be dropped at this point.

DETAILED DESCRIPTION.

On the Classification Card of the American Society of Bacteriologists in addition to the group number and the material given in Table II, there is a provision for the detailed characteristics of the organism in question. It was the original intention to present this description for the typical representative of each of the groups of cultures as given above, but when these descriptions had been prepared it was found that they were practically verbatim copies with the exception of the fermentation of sugar which has already been discussed. Accordingly the description of *Bacillus carotovorus,* Jones will be given and with the exceptions just noted this may be accepted as applying to the entire collection of cultures.

Bacillus carotovorus Jones.

For group number and brief characterization see page 264.

I. MORPHOLOGY.

1. Vegetative cells. Medium used, agar slope at 20-25 C. 1-2 days old; Form, *short rods, long rods, short chains, long chains;* Limits of size, .7 to 1 x 1.5 to 5; Size of majority, .8 by 2; Ends, *rounded.*
3. Endospores, *none.*
4. Flagella, 2 to 10; Attachment, *peritrichiate;* How stained, *Pitfield, Löwits, Fischer.*
5. Capsules, *none.*
6. Pseudozoogloea, *present, slight.*
7. Involution forms, *not observed.*
8. Staining reactions. Stains well in *watery fuchsin, gentian violet, carbol fuchsin, Loeffler's alkaline methylene blue;* Gram, *negative.*

II. CULTURAL FEATURES.

1. Agar slope. Growth, *abundant;* Form of growth, *filiform* to *spreading;* Elevation of growth, *effuse* to *raised;* Luster, *glistening;* Typography, *smooth* to *contoured;* Optical characters, *opaque* to *opalescent.*
2. Potato. Growth, *moderate* to *abundant;* Form of growth, *filiform* to *spreading;* Elevation, *effuse* to *raised;* Lustre, *glistening;* Typography, *smooth* to *contoured;* Chromogenesis, *white on all media;* Odor, *decided;* Consistency, *butyrous;* Medium, *grayed,* but *not discolored* in the customary meaning of that term.
4. Agar stab. Growth, *best at top, abundant, wide-spreading;* Line of puncture, *filiform.*
5. Gelatin stab. Growth, *best at top;* Line of puncture, *filiform;* Liquefaction, *crateriform* to *infundibuliform;* Begins on *2d day* at 20° C.; Complete in *6 days* with some cultures and *not in months* with others.

6. Nutrient broth. Surface growth, *pellicle thin* and *sometimes absent;* Clouding, *moderate* to *strong, persistent;* Odor, *decided;* Sediment, *compact* to *flocculent, usually abundant.*
7. Milk. Coagulation, *usually on 3d day* at 20° C.; Coagulum, *very slowly and slightly peptonized,* and not complete *in months,* digestion *not clearly evident to the eye;* Medium, slightly *browned.*
8. Litmus milk. *Acid, litmus reduced.*
9. Gelatin colonies. Growth, *rapid;* Form, *punctiform* to *round;* Depression, *crateriform;* Edge, *entire;* Liquefaction, *saucer.*
10. Agar colonies. Growth, *rapid* at 20-25° C.; Form, *round, occasionally irregular,* deep colonies *fusiform;* Surface, *smooth;* Elevation, *raised* to *convex; Edge, entire* to *undulate;* internal structure, *amorphus* to *coarsely granular* or even *grumose.*
13. Cohn's solution, *no growth.*
14. Uschinsky's solution, *abundant.*
18. Best medium for long continued growth is peptone bouillon.
19. Quick test for differential purposes. Slices of uncooked carrots, turnips and cabbages.

III. PHYSICAL AND BIOCHEMICAL FEATURES.

1. Fermentation tubes. Gas[25] produced in small amounts from *dextrose, lactose* and *saccharose,* but not from *glycerin;* Growth in the closed arm with *dextrose, lactose* and *saccharose,* but not with *glycerin;* Acid produced from *dextrose, lactose, saccharose* and *glycerin.*

3. Nitrates in nitrate broth *reduced* to *nitrites.*
4. Indol production *feeble.*
7. Optimum reaction for growth in bouillon in terms of Fuller's scale, 0.
8. Vitality on culture media, *moderate.*

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[25] See page 271.

9. Temperature relations. Thermal death point, 48-50° C.; Optimum, 25-30° C.; Maximum, above 38° C.; Minimum, below 10° C.
10. Killed *readily* by drying.
12. Sunlight. Exposure, not on ice, at midday in Sept. showed decrease after 1 minute, increasing to destruction of 90-100 per ct. after 20 minutes.

IV. Pathogenic to many fleshy vegetables of the North Temperate Zone.

CONCLUSIONS.

A considerable number of the cultivated plants in the North temperate zone suffer at times from a bacterial soft rot caused by a non-chromogenic, liquefying bacillus.

This comparative study of forty-three pathogenic strains derived from six different vegetables indicates that the results of fermentation tube tests with dextrose, lactose and saccharose offer the only usable cultural basis for differentiating these strains. However the cultures of the entire group have a weak fermentative power which, with very few exceptions, produces only a little more than enough gas to become evident in the fermentation tube. At other times the same strains produce no gas at all. These variations make the results of the fermentation tube test an unsatisfactory basis for classification.

Unless later studies of the pathogenicity of these cultures shall offer a basis for subdividing them, there is no apparent reason why they should not all be considered as somewhat variant members of a single botanical species.

II. PECTINASE, THE CYTOLYTIC ENZYM PRODUCED BY BACILLUS CAROTOVORUS AND CERTAIN OTHER SOFT-ROT ORGANISMS.

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II. PECTINASE, THE CYTOLYTIC ENZYM PRODUCED BY BACILLUS CAROTOVORUS AND CERTAIN OTHER SOFT-ROT ORGANISMS.[1]

L. R. JONES.

INTRODUCTION.

Two of our earlier publications (1900, 1901) have given detailed accounts of a bacterial soft rot of carrot and other vegetables due to the organism, *Bacillus carotovorus*. In the first of these articles it is stated (1901: 304, 312)[2] that "microscopic examination of the decaying carrot tissues has shown that the organism invades the intercellular spaces, and multiplies there with enormous rapidity. The middle lamellae of the adjacent cells appear to be softened or destroyed by the secretions of the bacteria, since isolation of the cells in invaded tissue occurs, but the bacteria have not been observed in the interior of the cells of the recently disorganized tissues. .... This (action on the middle lamella) is probably due to an enzym of the nature of cytase excreted by the bacteria. .... It seems probable that the further study of the bacteria concerned with the soft rots of plants will swell the list to a considerable number of organisms which resemble the above and each other more or less closely in their physiological characters."

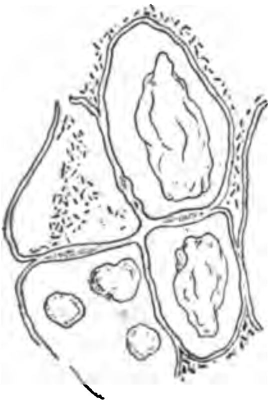

FIG. I. CARROT-ROOT PARENCHYMA IN EARLY STAGE OF DECAY CAUSED BY *B. carotovorus*. The cytoplasm is plasmolyzed and the bacteria confined to the intercellulars except where the wall has suffered mechanical rupture, as in the upper left-hand cell.

It appears, therefore, that a fuller understanding of the cell-wall-dissolving or other enzyms produced by such bacteria is desirable for two practical reasons: First, because the parasitism in each case seems directly associated with and probably dependent upon the power to produce such an enzym. Second, because these soft rot organisms are so much alike as to make the question of their specific relationship an extremely complex one which must ultimately be settled largely by appeal to physiological characters, including their ability in parasitism, and it would seem that their enzym production might prove of value in this connection as a differential character. Another interesting question of fundamental importance concerns the relationship of the cytolytic enzyms, or cytases, from various sources. We have attempted to determine whether the enzym here dealt with is identical with those obtained by de Bary (1886)[2] and Ward (1888) from certain fungi, by Brown and Morris (1890) and later investigators from seeds and by Potter (1899) and others from soft rot bacteria.

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[1] The laboratory studies upon the enzym here discussed were made during the years 1901–04, and this manuscript was prepared at their completion in 1904. Owing to the plan of cooperation, as explained in Part I, this pub-

In the progress of these investigations a detailed study was first made of the enzym as produced by the carrot-rot organism, including a comparison of its action when secured in various ways apart from the living bacillus, and also as observed upon the sundry vegetable tissues. Thereafter a comparison was undertaken of the characteristics of the enzyms secured from the soft-rot organisms of several other vegetables and finally with wall-dissolving enzyms produced by other classes of bacteria, by fungi and by germinating seeds. In the following discussion of the results it will conduce to clearness and directness of statement to follow a somewhat similar order. It might seem more logical to begin with a

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lication has awaited the conclusion of the associated morphological studies, except for a summarized account of the work which appeared in the "Centralblatt für Bakteriologie und Parasitenkunde," 1905, (see Bibliography). Inasmuch as no important contribution to the subject has come to our attention meanwhile, it has seemed best to leave the manuscript unaltered, and to add no titles to the bibliography later than 1905.

An important part of the work of the author was done in the botanical laboratory of the University of Michigan where he profited from the advice of Professor F. C. Newcombe. In the investigations carried on in his own laboratory in Vermont, valuable assistance was had from two of his students, Messrs. H. D. Bone and L. P. Sprague. He gratefully acknowledges his indebtedness to these gentlemen.

[2] All citations to the bibliography follow the plan of giving in parenthesis after the author's name the year of publication, followed where desired with the page numbers specifically referred to.

detailed discussion of the action of the enzym upon cell walls. In pursuance of the above plan, this is deferred and it must here suffice to state that the action consists in the softening and swelling of the walls and ultimately in the complete solution of their middle lamellae in susceptible vegetable tissues, but that in all cases it stops short of complete solution of the cell membrane, a residue of cellulose always remaining.

The studies here reported upon were carried on at various times during the years 1901-1904. The strain of the carrot-rot organism used has been the same throughout and is that isolated from decaying carrot tissues in 1899 and since carried in culture, practically all of the time in beef broth, at the ordinary laboratory temperature, 16°-22° C.

The question has arisen as to whether during this time reduction has occurred in pathogenicity and rate of enzym production. Van Hall (1903) found that his iris rot organisms lost pathogenicity to iris after only four weeks in laboratory culture and his experience with these led him to expect this as a rule with such organisms. Laurent's (1899) and Lepoutres' (1902) experiments suggest a like probability. Potter (1900: 445) found no such rapid loss of pathogenicity in his turnip rot organism.

In the case of *B. carotovorus* there has, in our judgment, been a considerable decrease in pathogenicity since our first trials of 1899. The change has, however, been a gradual one rather than rapid or radical, and, therefore, difficult to estimate. The virulence and rate of invasion of tissues has always varied with vegetables and environmental conditions, but it is certainly less vigorous in attacking even the more susceptible plants now than it was in our earlier inoculation experiments. A culture of this organism was sent to Messrs. Harding and Stewart of the New York Experiment Station in 1902. They reported it actively pathogenic at first, 1902, but wrote us a year later that it had lost practically all pathogenicity. Meanwhile our own cultures had not changed in any such radical way. In this connection it is worthy of remark that Harding and Stewart kept their culture on agar whereas ours were carried in broth. *B. carotovorus* is remarkably sensitive to desiccation as shown in our earlier work (1900: 328). It seems to us not unlikely that the weakening observed at the New York Station may have resulted from the intermittent desiccation incident to its culture on agar.

Exact estimates as to relative ability in enzym production shown now and formerly are even more difficult to make than are those as to pathogenicity. Our first isolations of enzym were made in 1901. We have compared some of the preserved samples of these earlier enzyms with those isolated in 1903. Those of 1901 were certainly more active than those of 1903. This difference might, however, possibly be accounted for by variations in medium and vigor of development as shown later in this article.

In our judgment, along with the loss of pathogenicity there has been a corresponding decline in enzym-producing power, but both of these have been so gradual as to be hard to estimate quantitatively.

The first thing undertaken in the course of these investigations was to determine whether the softening of the tissues associated with the invasion of this bacillus was certainly due to an enzym, and whether, if so, the enzym was separable from the organism. Five methods were tried with the object of securing such enzym, if it existed, apart from the organism, viz., (1) heat, (2) filtration, (3) germicides, (4) diffusion through agar, (5) precipitation by alcohol.

The first three methods involved, in all cases alike, the following procedures: The cultivation of the organism in beef broth for periods varying from three to fourteen days; the treatment of such cultures by the methods under trial; the determination of the sterility in the broth so treated; in case sterility was secured, the testing of the cytolytic activity of this sterilized broth by immersion in it of sterile blocks cut from fresh uncooked carrot or turnip roots, or from potato tubers or of cotyledon of immature pea; finally, tests to determine the continued sterility of the broth during this last trial period. In all cases where chemicals were used control trials were made to be sure that the chemical itself was not the cause of the changes observed.

STUDIES WHEREIN THE ENZYM WAS ISOLATED BY HEATING.

The thermal death point of the carrot-rot bacillus was carefully determined in connection with our earlier studies. It was found that recently inoculated thin-walled-tube cultures immersed for ten minutes at 51° C., or slightly under this, are rendered sterile.[8]

Previous studies (cf. Green, 1901: 98) upon cytolytic enzyms have shown that when in solution they are destroyed by heating to a temperature of 60°-65° C. It seemed probable, assuming that we are dealing with the same or a similar enzym, that there might be an intermediate temperature where the organism would be destroyed and the enzym left in the solution. This matter was tested by cultivating the organism in beef broth, heating these cultures to sterilize, making transfers to prove sterility and inserting bits of sterile carrot or other fresh vegetable tissues to determine enzym action.

The details of a single experiment will suffice to make clear the methods and aid in interpreting the results.

A series of six 10 c. c. beef broth cultures seven days old were immersed for ten minutes in a water bath of which the temperature was held at 55° C. These tubes were of thin glass about 15 x 1.5 cm. in size, immersed in the water three-fourths of their depth. The original reaction of the broth was +1.5%. To make sure of continued sterility transfers were made from the tubes soon after leaving the bath and again at the close of the experiment. Immediately after heating, a small block of living carrot tissue, cut from the interior of the root with proper precautions to insure sterility, was inserted into each tube. Like blocks of tissue were put into control tubes of each of two kinds, first, sterile uninoculated broth, and second, living broth cultures of the same age as the ones heated. The result was that the tissues in sterile uninoculated broth remained unsoftened, those in the living cultures rapidly softened and were fully decomposed in three or four days, while those in the heated tubes showed a similar but slower softening, requiring ten days for full action.

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[8] The above trials were first made in 1899 and repeated with like results in 1901. A careful repetition in 1903, using the same methods, showed a thermal death point fully one degree lower. This is doubtless the result of long cultivation in the laboratory. It is simply a matter of biological interest, which does not in any way affect the methods or results of the enzym studies discussed above.

In other experiments sterile blocks cut from turnip root and cotyledons of immature peas were used and were similarly softened. The results were fairly uniform and satisfactory. Various cultures so exposed at temperatures of 54°, 55°, 58°, 60°, 62°, 63°, 64°, 65°, 68°, 73° were rendered sterile in practically all cases. There was distinct cytolytic action in the sterile broths heated at the lower temperatures and none in those heated at the higher. There was, however, evident inhibition of activity even at the lowest of these as is shown in the experiment just described. Heating at 60°-62° inhibited the action to a marked degree as compared with 58° and in all cases, except one, heating at 62° entirely checked the activity. In only one case did any action occur in tubes heated at 63° and that was probably explainable on the ground of erroneous reading of temperature, since a repetition of the work gave results in harmony with the other series. No action occurred in any tube heated above 63°. The point of total inhibition of the cytolytic action as determined by this method, therefore, lay at or about 62° and there was marked decrease at all temperatures above 58°. Certain temperature relations will further be discussed later.

STUDIES WHEREIN THE ENZYM WAS SECURED BY FILTRATION.

It seemed probable that if the enzym were in solution outside the bodies of the bacilli it would pass through the porcelain bacterial filters and so be obtained apart from the organisms. Broth cultures of ages varying from seven to fourteen days growth have on six different occasions and with different bougies been passed through the Pasteur-Chamberland filters and the sterility and enzym content of the filtrate tested. There has been no difficulty in securing sterility with Pasteur-Chamberland filters, although earlier attempts with thinner walled and probably less perfect bougies were not successful.

Numerous trials were made by immersing in this sterile filtrate sterile cubical blocks cut from fresh roots of carrot and turnip and from potato tubers and also cotyledons of young peas, either fresh or those which had been for some time in sterile broth. In all cases alike these tissues were softened with solution of the middle lamella as in the presence of the living organisms. The detailed record of a single experiment will suffice.

In each of six tubes containing 10 c. c. of the sterile filtrate was introduced a carrot block about 3 mm. in diameter. At the end of twenty-four hours there was perceptible softening over the surface of these blocks and at the end of three days they were softened throughout. Potato blocks of similar size tested in the same way showed the first signs of softening on the fifth day and required ten days for complete softening.

These experiments and other similar ones that might be cited, including trials with razor sections under the microscope, showed that the lamella-dissolving enzym was in solution in the broth outside of the bodies of the bacilli. The question arose, however, as to whether the filtrate possessed the full enzymic activity of the original broth. It is conceivable that the bodies of the bacilli contain much of the enzym which gradually diffuses into the external liquid even after their death, and also conceivable that the filter may retain some of the enzym which was diffused in the original broth. To gain information on these points the enzymic activity of the filtered sterile broth was compared at various times with unfiltered broth cultures and with cultures of broths sterilized by the addition of chemicals. In one series of trials thin razor sections from roots of each carrot and turnip were immersed in (a) culture broth sterilized by filtration, (b) culture broth sterilized by a 20% addition of chloroform, (c) solutions of alcoholic precipitate from culture broth. The solutions (b) and (c) acted about alike, whereas (a) required at least twice as long to disintegrate the tissues. Similar trials made later using razor sections of turnip showed no difference of importance between the cultures containing the living organism and sterile broths like (b) and solutions like (c). A detailed discussion of these points occurs later.

Similarly sterile blocks from living carrot root were placed in the filtrate in comparison with like blocks in living cultures and others in broth plus 10% of chloroform to sterilize. The latter were shaken thoroughly and sterility proved. The carrot tissues in the living cultures and in the tubes sterilized by chloroform were alike softened in three days, whereas the blocks in the filtrate were more slowly acted upon, requiring nine days for full action. Still further evidence of this relation of filtration to enzym content was obtained by the method of alcoholic precipitation to be discussed later. Samples of filtered and unfiltered cultures were rendered 80% alcoholic and the filtered yielded only one-fourth as much of the enzym-containing precipitate as did the unfiltered. Moreover five per ct. solutions of each of these tested upon razor sections of carrot and turnip showed the enzymic action of the unfiltered fully twice as rapid as that of the filtered. Taking into consideration both the relative amounts and the relative strengths of these solutions, it would seem from this last trial that possibly four-fifths of the enzym was lost by filtration through the porcelain.

Comparisons and conclusions.—All these experiments give like evidence that passage through the Pasteur-Chamberland filters as used in these trials reduces decidedly the enzym content of the broth, although it does not remove all of it. Just why this retention of the enzym occurs has not been determined. As already suggested, this may be in part, at least, the enzym contained within the bacterial cells and which would later diffuse into the surrounding liquid; or it may be in part or wholly external to these cells either closely associated with the bodies of the bacteria and so retained with the bacterial slime in the porcelain; or it may be that the filter removes some of the enzym content which is diffused or in solution in the broth. The results of Freudenreich (1899) point to the latter conclusion. He attempted to clarify cheese extract for qualitative analysis by passing through Chamberland filters. He found that although the crystallizable and diffusible nitrogenous compounds (amids) passed through the bougies, some 90% of the soluble protein matter might be held back. Although all the bougies used by him retained considerable of the nitrogenous matter his trials showed that this passed much more fully through a new one than through the same after it had been used several times. In later trials (1900) he passed milk through these filters and found that the enzym galactase was removed thereby.

These experiments of Freudenreich came to our attention after we had completed our filtration experiments. In reviewing our records in their light we find that we used new filters or those which had been used for similar work only a few times. We are assured, therefore, that even the new bougies largely reduced the enzym content and that none that we employed, some of which had been used several times, wholly eliminated it.

The results of others who have tested the relation of filtration to enzym content of cultures of similar soft-rot bacteria may profitably be reviewed in this connection.

Potter (1900: 448) found that filtration through Pasteur-Chamberland filter did not remove the enzym produced by his *Pseudomonas destructans*. Laurent (1899) found similar bacterial enzyms to pass through porcelain while Spieckermann (1902) found that after passing culture broths through the Reichel porcelain filter the sterile broth had not the least enzymic action. Van Hall (1902) found that the juice expressed from potato decayed by the invasion of *B. subtilis* when passed through the porcelain filter retained the property of rapidly destroying the potato tissue. He also found (*Zeitschr. f. Pflkr.*, 1903) similar but weakened action in the juice from iris invaded by his *Bacillus omnivorus*, when this was passed through a porcelain filter. In other trials he found filtered broths lost all activity. We are at a loss to reconcile some of these results with our own and the others except by appealing to differences in the filters.

STUDIES WHEREIN THE ENZYM WAS ISOLATED BY THE USE OF GERMICIDES.

The preceding results were satisfactory so far as they went, but it was manifestly desirable to find some simpler method of procedure. Two serious objections to the preceding methods should be eliminated if possible, namely, first, that precautions are necessary to insure the sterility of the broths during prolonged study subsequent to filtration; and, second, the ever-present danger that the method used to eliminate the organism may at the same time remove or weaken the enzym. It seemed probable from the experience of others who have studied similar enzyms that some chemical added to the cultures would kill or wholly inhibit the bacillus without destroying the enzym or interfering with its activity. With this hope, trial was made of additions of formalin, phenol, thymol, and chloroform, respectively, to beef broth cultures. In considering the results reference was also made to related experiments, to be discussed in detail later, where similar additions of these chemicals have been made to solutions of the enzym-containing alcoholic precipitates.

FORMALIN.

The relation of formalin, both to the life of the organism and to the activity of the precipitated enzym, has been determined. It has been found that both the organism and the enzym are extremely sensitive to this chemical. Since, however, the organism is more so it is possible so to gage the amount as to sterilize the broth and leave the enzym active. These conclusions are based upon experiments made by the addition of varying proportions of formalin, both to the beef broth cultures and to solutions of the precipitated enzym. Some hundreds of such additions have been made to beef broth cultures, including the following strengths, and numerous trials each of many of them: Formalin 0.03%, 0.06%, 0.08%, 0.095%, 0.18%, 0.33%, 0.46%, 0.57%.

The detailed account of a single series will suffice to explain the general method and results. All this work was carried on at temperatures of 18°-22° C.

To ten broth tube cultures, 10 c. c. each, formalin was added as follows and the tubes then thoroughly shaken: Two tubes (1 & 1′), 0.57% formalin; two tubes (2 & 2′), 0.46%; two tubes (3 & 3′), 0.33%; two tubes (4 & 4′), 0.18%; two tubes (5 & 5′), 0.095%. Two tubes (6 & 6′) containing sterile broth were included to serve as controls. On the third day transfers made from these to sterile broth proved the sterility of all. On the fifth day a sterile cube 5 mm. in diameter, cut from the interior of fresh carrot was inserted into each tube. On the eleventh day the carrot tissues in tubes 1, 1′, 2, 2′, 3, 3′, 6, 6′, were not softened; those in 4, 4′, 5, 5′, were completely softened. On the fourteenth day 3, 3′, were softened somewhat; others unchanged. On the twenty-third day 3, 3′, further softened; 2, 2′, softened somewhat but less than 3, 3′. On the thirty-third day 1, 1′, and 6, 6′, showed no softening; others completely softened. Final transfers to sterile broth showed all tubes sterile at the close of the trial.

As a result of similar series, repeating the above and using other strengths of formalin, the following conclusions have been reached. The addition of 0.1% formalin is sufficient to sterilize a beef broth culture of *B. carotovorus* one to ten days old, providing the tube is thoroughly shaken. More formalin, 0.2% or even more, may be needed if not thoroughly shaken. The presence of 0.6% or more formalin completely inhibits enzym action; amounts as low as 0.3% retard to a marked degree. There was perceptible retardation from 0.06% formalin, although this amount was too slight to sterilize with certainty. In all the above trials the formalin acted on the broth several days before its relation to the enzymic activity was determined.

Trials were also made to determine the effect of formalin additions to solutions of the enzym obtained from broth cultures by precipitation with alcohol. The activity in these cases was determined by trial on razor sections of carrot roots. The results were in accord with those just discussed, viz., a slight but appreciable retardation from 0.05% addition, and almost complete inhibition where 0.5% was added. In these latter trials the formalin was added to the enzym solution some time before the cytolytic activity of the mixture was determined. The results led us to abandon further work with formalin.

After the preceding work with formalin was completed, however, Spieckermann's article (1902: 166) reached our hands in which he reports that a 0.2% solution of formalin sterilized the cultures of the soft-rot organism of cabbage with which he was working and did not inhibit the action of the cytolytic enzym, *at least for several hours.* We, therefore, undertook to learn the relative rate of action of formalin upon each, *B. carotovorus* and its enzym, by adding to broth cultures 0.2% of formalin, shaking thoroughly and testing both viability and enzym action at frequent intervals. It was found in the first series of trials that at the end of twenty-four hours the activity of the enzym was not appreciably lessened; at the end of forty-eight hours there was slight retardation and this was pronounced at the end of seventy-two hours. On the other hand transfers at the end of only three hours showed most of the organisms to be dead or so affected that growth was slow in starting and at the end of forty-eight hours the broth was sterile.

In a second series of trials the broths were tested at more frequent intervals. This again showed the organisms to be killed before the enzym was fully destroyed, but the retardation was more pronounced than in the preceding trials. The details are as follows:

1. Action on enzym:—Broth cultures six days old; formalin added to make 0.2% solution, thoroughly shaken; cytolytic action compared with control tubes by testing upon thin sections of turnip. Result: After three hours slight retardation was evident; after six hours nearly twice as long a time was required for the same results in the formalin solution, i. e., formalin retarded the action 50%; after twenty-four hours still more difference; after forty-eight hours formalin solution required five times as long as control; after eighteen days it required sixty hours to disorganize sections, whereas the control broth did this in one hour.

In a third series, little if any retardation up to the sixth hour; after nine hours the action of the formalin broth required twice as long; after twenty-four hours it required four times as long.

2. Action on the organism:—Formalin to make 0.2% solution was added to broth cultures, thoroughly shaken; transfers at the end of each two, three, six, and nine hours showed growth. There was, however, progressive retardation. Thus the control was clouded in less than twenty-four hours; that made at the end of two hours showed clouding first on the third day; that at the end of three hours first clouded on the fifth day; six hours, on the seventh day; nine hours, on the twelfth day. After clouding appeared growth progressed with normal rapidity.

These results show sufficient variation between the different trials to forbid sweeping generalizations. They agree, however, with each other and with Spieckermann's results in showing that the action on the organism is more rapid than on the enzym. There was no appreciable retardation of the enzym action until after a period varying from three to nine hours, or in one case twenty-four hours, whereas there was marked inhibition in growth of the organisms after two or three hours. These results were of such a nature, however, as to discourage us from looking to the use of formalin as a practical method of sterilizing broths preparatory to the study of the normal action of the enzym. If used within two or three hours as Spieckermann directs, sterility is not insured; if a longer time elapses, the activity of the enzym will be reduced quantitatively at least and conceivably affected qualitatively.

Bliss and Novy (1899: 52) have shown that fibrin, which has been acted upon for a short time by formalin, resists thereafter the digestive action of proteolytic enzyms. These observations raised the question as to whether the retardation in the cytolytic action already noted might be in any degree the result of the action of the formalin on the wall of the vegetable tissues rather than upon the enzym itself. In order to determine this, razor sections of turnip and radish were immersed twenty-four hours in full strength formalin, then washed out in water, and the rapidity of action of enzym solution on these compared with that on freshly cut sections and on those which had lain twenty-four hours in absolute alcohol. Other similar trials were made where the tissues had lain a month in either formalin or in absolute alcohol, respectively. All were promptly and similarly decomposed, there being no evidence of difference in this respect. The inhibiting action of formalin must, therefore, be attributed to its effect on the enzym itself rather than on the tissues. It is interesting to note in this connection that Bliss and Novy (1899: 79) found formalin to inhibit certain enzyms (papain, trypsin, amylopsin) and not others (pepsin, malt diastase). Von Freudenreich (1900), experimenting upon milk enzyms, found that formalin tends to lessen the action of galactase more promptly than it does that of pepsin and pancreatin.

It is surprising that Potter (1900: 448) was apparently unable to destroy with formalin the organism causing white rot of turnip. We are led from our experiments to believe that larger amounts of formalin or more thorough agitation would have accomplished this.

PHENOL.

Seven trials of this, each involving several cultures, were made with uniformly satisfactory results. A piece of the crystal varying in size from one-fourth to one-half that of a pea, (i. e., making 0.3% to 0.6% solution) added to a 10 c. c. broth culture and well shaken has never failed to produce sterility and there is apparently no retardation of the activity of the enzym. To cite a single experiment:

A crystal of phenol half size of a pea, i. e., making about 0.5% solution was added to each of six 10 c. c. broth cultures six days old and thoroughly shaken. On the second day thereafter transfers were made to test sterility. No growth having developed from these transfers seven days later, sterility was inferred and a cube of sterile fresh carrot about 5 mm. in diameter was added to each tube. In two days' time all these pieces of carrots were fully softened. When compared with other tubes sterilized by thymol or chloroform and with those containing the living organism such phenol tubes showed no evidence of retardation.

In other trials it was found that additions of 0.1% and less of phenol failed to sterilize and, on the other hand, additions of 5% or more totally inhibited the activity of the enzym. The phenol was added to the culture in these experiments four days before the enzymic activity was tested.

THYMOL.

This proved less satisfactory as a germicide than phenol, but chiefly, we think, because of its slight solubility and slow diffusion in the broth. If the alcoholic solution is used the thymol is precipitated upon contact with water, hence there is no gain. Our trials have shown that powdered thymol, which floats on the surface of a broth culture, will sterilize the surface layer, but that where the culture has stood without shaking, living organisms persist, at least for many days, in the deeper parts of the broth. For this reason even large amounts of thymol will fail to sterilize in the absence of agitation, whereas sterility can be secured with small amounts by thorough shaking. The following experiments will serve to show this.

A large excess of thymol (2%) was added to each of ten broth tube cultures eight days old and a small amount (about 0.2%) to each of ten similar tubes. All of these were left without agitation. Transfers made on the eighth day thereafter showed living organisms in four of the tubes containing the larger amount of thymol and in five of those with the smaller amount. On the tenth day living organisms remained in three tubes of each series. In another series a crystal of thymol equalling about 0.2% of the broth was added to each of three ten c. c. broth tube cultures four days old and a tiny crystal of about one-fourth this size to each of three other similar cultures. These were all thoroughly shaken. Transfers from these tubes on the second day thereafter showed living organisms in all three of these containing the lesser amount, but the others were sterile. In all cases pieces of sterile carrot inserted into tubes sterilized by thymol have been quickly softened without evidence of inhibition.

In comparison with the above results it is of interest to note that Potter failed to sterilize cultures of his turnip white-rot organism by the use of thymol (1900: 448); but the possibility remains that more agitation would have secured sterility in his cultures.

E. F. Smith (1901) found that certain organisms will grow in beef broth in the presence of thymol, but his statements would indicate that there was little or no agitation of the broth. These results force us to question whether full dependence can be placed on some of the results of Bourquelot and Herissey's work on pectin enzyms, as discussed later in this article, since they, apparently, depended on additions of thymol water to insure sterility.

CHLOROFORM.

Since this is the agent usually employed in enzym studies for the inhibition of bacterial growth especial attention has been given to the determination of its relation both to the organism and the enzym.

The first experiments to determine this were carried out in 1901. In these Powers & Weightmann chloroform of "U. S. P. standard" strength was used. This was added to broth tube cultures, seven to nine days old, in amounts to give proportions varying in different experiments from 10% to 50%. These tubes were shaken, then allowed to stand and stratify. The excess of chloroform promptly settled to the bottom, but such tubes continued to emit a strong odor of chloroform throughout the experiments. Transfers made three days later showed the cultures to contain living organisms in all cases.

During the year 1903, these trials were repeated, using both Mallinckbrodt's "M. C. W. purified" chloroform and the "U. S. P." grades both of this firm and of Powers and Weightman. These later results were alike in all trials and differed from those made in 1901. In every one of these later cases where 10% or more of chloroform was used and *the tubes thoroughly shaken* sterility was secured.

The details of a single trial will suffice to illustrate the method and results. Chloroform was added as follows to each of six 10 c. c. broth tube cultures, six days old, shaking very thoroughly; to tubes 1 & 1′ added 1 c. c. of chloroform; to tubes 2 & 2′ added 0.5 c. c. of chloroform; to tubes 3 & 3′ added 0.3 c. c. of chloroform. On the third day thereafter transfers from these showed 1 & 1′ to be sterile, whereas the others contained living organisms. On the fifth day transfers from these latter again showed living organisms. Cubical blocks of fresh carrot were placed in tubes thus sterilized with 10% additions of chloroform and in other similar series sterilized by 25% and 50% additions respectively, and in all cases alike they were quickly and fully softened.

There was no appreciable retardation in the rate of softening in any such case as compared with tubes sterilized with thymol or phenol, or even with cultures containing the living organisms.

This matter was of so much importance that further comparative trials were made by using razor sections of turnip. There was no appreciable difference in the rate of softening as between living cultures and those sterilized by chloroform. Thus in one trial, broth cultures four days old were used; 10% of chloroform was added to each of two of these; after thorough shaking immediate trials were made comparing the activity with that of similar cultures; no difference was found. Again, at the end of the sixth day when the chloroform tubes were sterile, comparative trials showed the sterile broth to equal in enzymic activity the living control cultures, now ten days old.

Comparisons and final conclusions.—These results showed chloroform to have no inhibiting effect upon the enzym when used even in great excess and proved the efficiency of chloroform as a germicidal agent in such work as we were doing. At the same time they emphasize the need of painstaking and caution if chloroform is relied upon, either to sterilize cultures or to preserve sterility of enzym solutions as is so frequently done.

A comparison of these results with those obtained by others will again prove helpful.

Brown and Escombe (1898: 16) satisfied themselves that the cytolytic enzym of barley is not appreciably weakened in its action by a saturated aqueous solution of chloroform. Smith (1901) has called attention to the fact that many organisms are surprisingly resistant to chloroform and emphasized the point we have just made, as to the need of caution in its use. Potter (1900: 448) did not succeed in sterilizing cultures of the turnip white-rot organism with chloroform, but Spieckermann (1902: 166) found chloroform effective for sterilizing the sap of vegetables invaded by his kale rot organism. He does not state the amount used nor the method of agitation, but it was, presumably, used liberally, and thoroughly shaken. He reports no appreciable retardation of the enzym by it unless it be a gradual weakening after long standing of fifteen days or more. His results were, therefore, similar to ours.

Van Hall (1903) used chloroform in his work upon his *Bacillus omnivorus*. His results are surprisingly at variance with those of all these others, since he found the addition of even 0.5% of chloroform destroyed all trace of activity in bacterial juices in one-fourth of an hour. We are unable to reconcile this with our experience and in view of all the evidence must believe him in error in his interpretation of results.

A COMPARISON OF THESE GERMICIDES.

The trials of the chemicals previously mentioned were conducted at about the same time and there were frequent opportunities for comparisons. Toward the close of the work a special series of trials was planned as follows in order to reach more definite conclusions upon the comparative effect of these chemicals on the activity of the enzym.

A series of ten broth cultures (10 c. c. each) five days old was treated as follows:

To each of two tubes No. 1 & 1′ added 1 c. c. of purified chloroform making 10% solutions. To each of two tubes No. 2 & 2′ added 0.5 c. c. of 2% formalin making 0.1% solutions. To each of two tubes No. 3 & 3′ crystal of thymol (about 0.05 g., i. e. 0.5%). To each of two tubes No. 4 & 4′ crystal of phenol (about 0.5 g., i. e. 5%). Two other tubes were included in the series; one of these, No. 5, contained sterile broth in which the organism had grown for seven days and which had then been rendered sterile by passage through the Pasteur-Chamberland filter. The other, No. 6, contained a living culture of the organism, five days old. Three days later transfers made from each tube except the last proved sterility. On the same day a sterile cube cut from living carrot root was inserted into each of these tubes. Forty-eight hours thereafter the carrot tissue in tubes 1, 1′, 3, 3′, 4, 4′ and 6 were alike well softened, there being no evidence of inhibition by any of these chemicals and no greater softening in the presence of the living organisms than in these sterile tubes. The carrot in the filtrate (5) was considerably less acted upon and formalin (2 & 2′) showed still less softening. Further examination showed full softening in these latter tubes (2, 2′ & 5) at the end of nine days. Transfers at the close of the experiment proved continued sterility in all the tubes except one of those containing chloroform.

These confirmed the evidence from previous trials and led us to conclude that neither chloroform, thymol nor phenol had any inhibiting effect on the enzym; that well developed broth cultures sterilized by the addition of any of these possessed as active cytolytic properties as that in which the organisms continued alive; that formalin inhibited the enzymic activity; that filtration through porcelain reduced the enzym content.

To preclude the possibility of error because of the softening action upon the vegetable tissues of the broth itself, or of any of these chemicals, a series of control tubes was held in which carrot blocks were immersed in sterile broth without any added chemical and in similar ones in which the various chemicals were added in the amounts indicated in the above experiments. These carrot tissues in all cases remained unsoftened.

SECURING THE ENZYM BY DIFFUSION.

Our observations upon decaying vegetables have shown that the cell walls are affected some distance in advance of the invasion of the organisms. This would indicate the diffusion of the enzym through the intermediate tissues as was observed by de Barry (1886) in the case of *Peziza* and by others with similar parasitic invasions. When this first came to our attention it suggested the possibility of testing the diffusibility of the enzym through some medium impenetrable to the bacteria, partly as confirmatory of the above explanation and partly as another method of studying the action of the enzym apart from the organisms. Before we got to the point of undertaking this, however, van Hall's (1902: 649) paper came to hand in which he describes his similar attempts and their very interesting results. In his studies upon his *Bacillus omnivorus* he employed a modification of the plan developed by Beijerinck in his studies upon the mosaic disease of tobacco. Van Hall's method consisted in growing his organism in streak cultures upon the surface of agar, then cutting off a surface layer from this, carrying the streak, and transplanting the layer to potato. In this way he secured the softening of the potato underneath the streak. In other cases he removed sterile bits of agar underlying the culture and transplanted them to sterile vegetable surfaces for trial.

We found the method outlined in the following experiment a more convenient way of securing the same result.

Beef broth agar, two per cent, was poured into small petri dishes to a depth of about 3 mm. When this had hardened and the surface dried slightly, *Bacillus carotovorus* was implanted on the surface of a small area at the center. At the end of three days a good surface growth was thus secured about 1 cm. in diameter. A slice somewhat larger than this layer of agar was then cut from the interior of a fresh turnip root and placed in a large sterile petri dish, using caution to avoid contamination. The layer of agar from the smaller dish was then carefully lifted with sterile instruments and placed upon the surface of this turnip slice in the larger dish and covered to prevent contamination. This was designated A. The details of the method may become clearer upon examination of the accompanying figure. Two other dishes, B and C, were prepared in like manner at the same time. A layer of sterile agar was laid in a fourth dish upon a turnip slice as a control and designated D.

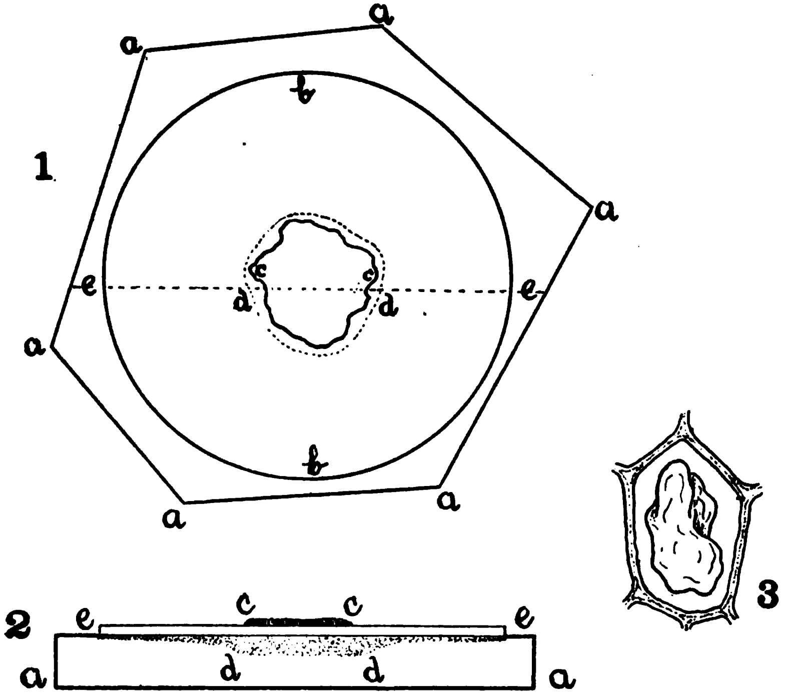

Fig. 2. Diagrams to show method and results of testing the diffusibility of the enzym through agar.

No. 1, surface view; 2, vertical section of the same along dotted line e–e; a–a, sterile slice of living turnip root; b–b, layer of nutrient agar bearing the bacterial colony c–c; d–d, region of most active enzymic action; the extent of softened tissue at the end of 24 hours is indicated by the dotted area in No. 2; No. 3 shows a single cell of this softened turnip tissue.

At the end of twenty-four hours, examination of this control, D, showed the turnip underneath the agar to be unchanged, except for a slight yellowish stain imparted by the agar to the surface; no softening whatever had developed. Upon lifting the agar in the first dish, A, the turnip showed an area immediately underlying the colony and somewhat larger than the surface spread of this in which the tissues were slightly browned and softened exactly as where invaded by the organism. Bits of this rotten turnip tissue were immediately transferred to each of three broth tubes to test sterility. In none of these, neither in any of several similarly tested later, did growth develop, showing beyond question that this softening of the tissues was due solely to the bacterial products which diffused through the layer of agar from the surface colony above. Upon more carefully examining the turnip slice it was found that there was a slight softening of the surface over the entire area covered by the agar, b-b, of the diagram Fig. 2. The area immediately underlying the colony was softened much more deeply however, viz., about 1-1½ mm. The deepest softening occurred in a circle about 2 mm. wide underlying the margin of the colony, lying between d and d in the accompanying diagram, (Fig. 2). Microscopic examination showed exactly similar conditions to those which accompany bacterial invasion, viz., isolation of the cells as a result of the solution of the middle lamellae, with the residual walls swollen and taking a blue stain upon treatment with chlor-zinc-iodide, and the protoplasmic contents showing granulation and plasmolysis.

Several other dishes examined after twenty-four to thirty-six hours show results practically like the above except that in most of them the softening was to a uniform depth of 1-2 mm. immediately underlying the colonies with a gradual decrease in this depth, as shown in the accompanying diagram which is drawn to exact scale as to size of colony and degree of softening at the end of twenty-four hours.

In connection with the above work we also conducted similar transplantations of colony-bearing layers of agar to the surface of sterile gelatin plates. Examination in such cases at the end of three days revealed liquefaction of the gelatin underlying the colony, but for an area equalling about twice the diameter of the colony above, and to a depth of one to two millimeters. Transfers from this liquefied gelatin to broth tubes proved its sterility and showed that the action here, as in the case of the vegetable tissues, was due to the diffusion of the bacterial products from the colony through the intervening agar.

SECURING THE ENZYM BY PRECIPITATION WITH ALCOHOL.

Strong alcohol added to bacterial culture broths gives a flocculent whitish precipitate which includes not only the enzyms present, and various proteid matters, but also carries the bodies of the bacteria down with it. This is the commonest method of securing enzyms in bacteriological investigations and is, therefore, in a measure a standard for comparative work. It also has advantages over the other methods especially in that it is possible easily to preserve this dried precipitate for indefinite periods. For these combined reasons it was used in much of our work. We have found that 25 per cent of alcohol is fatal to the carrot-rot organism in broth cultures and since more than that amount was used in all our precipitation work, it is evident that this method insures the elimination of the living organism.

METHODS.

Several questions arose at the beginning as to methods which we will discuss under the following heads:

1. *Filtration.*—The first of these was as to whether the alcohol should be added directly to the culture broth, thus giving a precipitate containing the bodies of the bacteria, or whether it is preferable to remove the bacteria by passing the broth through a porcelain filter before precipitation. The trial reported on a preceding page showed that the filtered broth when tested directly possesses less enzymic activity than does the unfiltered broth. As is there shown, the precipitate obtained when such broth is rendered 80% alcoholic similarly has less enzymic strength than the precipitate from unfiltered broth. After a few trials had determined these facts all subsequent work along this line was with culture broths which had simply been passed through filter paper.[4] This filter re-

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[4] Some students of cytolytic enzyms have objected to the use of filter paper because of the possible action of the enzym upon it. This occurred to us early in our work but repeated observations have shown this enzym is entirely inactive on the celluloses proper. We have, therefore, used Schleicher & Schull's filter paper, both for filtering the broths and for collecting the precipitate.

moves the coarser deposits but not the bodies of the bacteria. To the filtrate was then added enough 95% alcohol to render it alcoholic to the desired degree, usually 80%, the precipitate allowed to settle, the supernatant alcohol siphoned off, the precipitate, collected on filter paper, washed with either 95% or absolute alcohol and quickly dried, partially in a current of warm air, then in a desiccator over sulphuric acid. The dried precipitate, which is gray and somewhat brittle, was then powdered before redissolving in water. It is of course important to secure quick drying to avoid the possibility of alteration as a result of bacterial growth or of chemical changes in the precipitate. The drying must also be done at so low a temperature as to preclude danger of injury from heat to the sensitive enzym. In our earlier work we washed out the 95% alcohol with absolute alcohol in order to hasten the drying. Later it was found this made scarcely any difference in the time and no difference in the result, providing the moist precipitate was properly broken up so as to dry out quickly. Spieckermann (1902: 165) used absolute alcohol followed by ether, presumably to secure quick drying. Most of our work had been completed before his paper reached us, but we thereupon tested this method in comparison with that followed by us and have found it unsatisfactory. The precipitate when the ether was used showed a diminution in its enzymic activity providing it stood in the ether long enough to displace the alcohol. Thus, holding the precipitate in ether one hour, while it did not injure it, made no appreciable difference in its rate of drying; where in ether fifteen hours, it was only two-thirds as active and required almost as long for drying; where in ether for twenty-four hours it dried quickly, but possessed only one-fourth the activity of that dried directly from 95% alcohol. While a solution of the latter softened radish and turnip tissues in fifteen minutes, the former required one hour to accomplish the same result.

In further trials chloroform was used with part of the precipitate and ether with another part to remove the alcohol with a view to hastening the drying. Thus one-half of the precipitate was dried immediately after washing with 95% alcohol. The balance was immersed for nineteen hours in absolute alcohol, then for forty-eight hours in chloroform,[8] changing the chloroform once during this period. Upon its removal from this fluid the precipitate quickly dried to a chalky, brittle, white mass. Comparative trials, using 5% aqueous solutions of the precipitate dried from the 95% alcohol and that where the chloroform was used, showed them to be equally active. These results established our confidence in the method of drying, directly from 95% alcohol and we have therefore continued so to do as it is more economical of both chemicals and time. We would again say, however, that its most successful use is in our judgment conditioned upon quick drying secured by breaking up the moist precipitate and placing it in a current of dry, warm air. Inasmuch as we found the use of ether injurious to the enzym and van Hall (1903) says that chloroform destroyed it in his trials, it is at least incumbent on anyone who employs either of them to determine their safety. It is, of course, possible that even with the same enzym secured from different broths and in mixture with different compounds there might be different results with the same chloroform or ether, and even more likely that some brands of ether or chloroform might carry in solution substances acting deleteriously upon so sensitive a compound as these enzyms.

2. *The most favorable strength of alcohol.*—Precipitation with various percents of alcohol was tried early in the work to determine the relative amounts and strengths of the precipitates thus secured.

In the first trial, using beef broth cultures five days old and increasing the alcohol at four steps, fractional precipitates were secured as follows:

At alcoholic strength of 20%, a mere trace of precipitate was secured.

At alcoholic strength of 40%, secured 15% of total precipitate.

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[8] Mallinckbrodt's ' M.C.W" brand.

At alcoholic strength of 80%, secured 80% of total precipitate.

At alcoholic strength of 90%, secured 5% of total precipitate.

Trial of the last three precipitates (i. e., 40%, 80%, 90%) on carrot sections showed all to have cytolytic activity, but that from the 90% had distinctly less than did the others. Between those of 40% and 80% there was no noteworthy difference. In a second trial the culture broth was divided into three lots of 150 c. c. each, and each lot treated separately as follows:

Lot 1, made 40% alcoholic, gave 0.005 g. precipitate, or 1% of total.

Lot 2, made 60% alcoholic, gave 0.065 g. precipitate, or 14% of total.

Lot 3, made 80% alcoholic, gave 0.390 g. precipitate, or 85% of total.

Trials of these precipitates on carrot and radish sections showed those from lots 2 and 3 to be of excellent activity and about alike, whereas that from 1 required twice as long to soften the sections.

Since in both of these trials the 80% alcohol secured practically all of the enzym, and this in a state of the highest activity, that strength alone was used in all subsequent alcoholic precipitation work.

3. *Reprecipitation.*—The precipitate obtained by the addition of alcohol to the broth is, of course, composed only in part of the enzym, the larger portion being presumably other proteid matter. In the hope of securing a purer state of the enzym a re-solution and second precipitation with alcohol was made as follows:

Two grams of the dry powdered precipitate obtained from beef broth cultures was added to 400 c. c. of distilled water, the solution placed on ice and frequently shaken. At the end of four hours one-half was filtered off and, since filtering through paper did not remove the undissolved precipitate, it was clarified by passing through a porcelain filter, then reprecipitated by rendering 80% alcoholic. The balance stood twenty-four hours on ice and was then filtered through six inches of calcined sand. This cleared it up but slightly. Sufficient alcohol to make this an 80% solution was added and the precipitate collected and dried. Comparisons were then made between like solutions of this reprecipitate, of that passed through the porcelain filter, and of the original. That passed through the filter was scarcely equal to the original in strength; that passed through the sand was slightly stronger, but not enough so to be of practical consequence. Reprecipitation was therefore considered of little advantage and was not tried further.

4. *The relation of strength of solution to activity.*—When this dried alcoholic precipitate is added to water it swells promptly, but apparently only a small fraction of it is dissolved. Two questions arose early in our work: first, as to the relation of the strength of this solution to the activity of the enzym; second, as to the relative enzymic activity of (a) such solutions of the precipitated enzym and (b) of the original broth cultures from which the precipitates were secured.

To determine the first point amounts equal to 1%, 5% and 10% respectively were added to distilled water, plus chloroform, and their relative activities compared on carrot and turnip root sections. The results in all cases showed the activity to increase with strength of solution, but not proportionately. The average of several trials led to the conclusion that, with the precipitate used, it required twenty-five minutes in the 1% solution to secure as complete enzymic action as was secured in fifteen minutes in the 5% solution and in ten minutes in the 10% solution; that is to say, the relative activities of the 1%, 5% and 10% solutions stand in the ratio of 6, 10 and 15.

Our practice in all of the work here reported with alcoholic precipitates has been to use 5% solutions unless otherwise stated.

The second question is of quite as great interest, since it involves the query as to whether the enzym is or is not injured by the action of the alcohol.

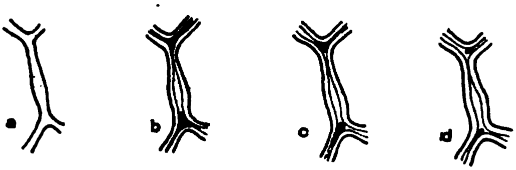

FIG. 3. STAGES IN THE ACTION UPON WALL OF THIN SECTION OF CARROT ROOT IMMERSED IN A 5 PER CENT SOLUTION OF THE BACTERIAL ENZYM SECURED BY PRECIPITATION WITH ALCOHOL.

Normal wall shown in a; b, same, 7 minutes after immersion; c, after 13 minutes; d, after 30 minutes action when only minute traces of the middle lamella remained. The cells lose coherence after the stage shown at b is reached (Camera lucida).

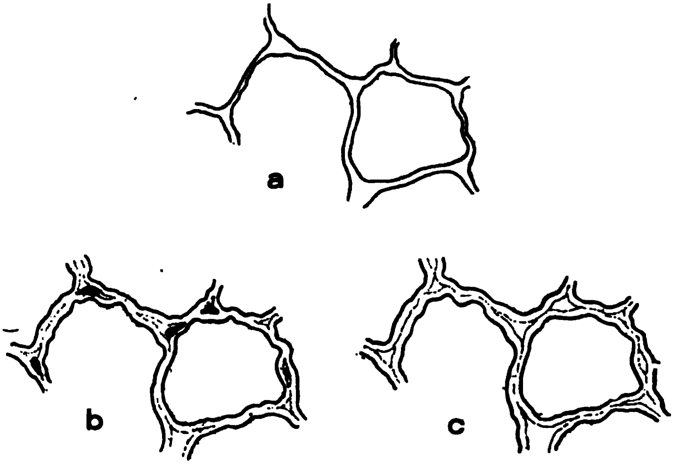

FIG. 4. A SERIES OF CAMERA DRAWINGS FROM ANOTHER SECTION OF CARROT ROOT IMMERSED IN 5 PER CENT SOLUTION OF THE ENZYMIC PRECIPITATE. The normal walls shown at a; b, the same after 12 minutes; c, the same after 32 minutes action.

In general, the beef or vegetable broth cultures yielded from 0.2 g. to 0.4 g. of the dry alcoholic precipitate for each 100 c. c. of broth. It is evident that the 1% solutions of this precipitate should contain some three times as much of the enzym as did the original broth cultures, providing that the precipitation and the re-solution are complete. On the other hand it is quite conceivable that the enzym may be injured by precipitation, in which case the aqueous solution of the precipitate might show weaker enzymic action than the original broth.

To test this matter a portion of the precipitate from a six day beef broth culture was added to a volume of water equalling that of the original broth (0.015 g. of precipitate in 5 c. c. of water, equalling 0.3% solution). The activity of this solution was then compared with that of a like broth culture sterilized by the addition of chloroform, and of third sterilized by passage through a Pasteur-Chamberland filter. The results were that the first and second showed practically the same degree of enzymic activity, whereas the third showed less than half as much. These comparative trials were repeated on a later occasion. Here we used (a) the juice expressed from a turnip decayed by *B. carotovorus,* inoculated three days previously; (b) an aqueous solution of the alcoholic precipitate obtained from a similarly decayed turnip, so made up that the volume of water equalled that in the original juice from which the precipitate came. No chloroform was added to (a), the living culture being used. Trials of these on turnip and carrot sections showed the enzymic activity of (b) to be fully as great as that of (a). The results of Spieckermann (1902: 166), which reached us after the earlier trials were made, are in accord with these. It is surprising that no loss occurs through precipitation and re-solution of a compound so sensitive as this enzym shows itself to be in many ways.

In these trials the original broths and the aqueous solutions of a strength equalling them have proved on the average less than one-third as active as the 5% solutions which we have used in most of our trials with the precipitate; that is to say, these 5% solutions have rotted the vegetable sections in less than one-third the time required to do this where the sections are immersed in the living cultures.

RELATION OF CULTURAL CONDITIONS TO ENZYM PRODUCTION.

THE MEDIUM.

The vigor of growth of the organism varies widely, of course, with the composition of the medium and with other cultural conditions such as age and temperature. Various experiments were undertaken to determine the relation of these matters to enzym formation, having in mind especially the conclusions of some previous investigators that enzym production in certain cases is a starvation phenomenon.

De Bary (1886) looked upon the disorganization products of the enzym of *Peziza sclerotiorum,* which dissolves the middle lamella of the cell walls of various plant tissues, as the chief source of the nutrition of the fungus mycelium. He thought some sugar, available as food for the fungus, to be the product of the enzym action on the host cell walls. He considered, however, that the enzym was similarly concerned with action upon the protoplasm of the host.

Ward (1888) concluded that the similar wall-dissolving enzym produced by the lily Botrytis is a starvation phenomenon. Brown and Morris (1890) consider starvation to be a stimulus to cytase as well as diastase secretion in germinating barley. They also (1893) found that diastase formation occurs more actively in leaves during the night and concluded that this is attributable to the exhaustion at that time of soluble food, and hence is to be classed as a starvation phenomenon.

Careful comparisons have been made as to the enzym product from growths upon several media[6] varying widely in nutritive elements and especially in carbohydrate content. These have included:

1. Dunham's peptone solution (1% Witte's peptone, 0.5% sodium chloride); a medium upon which this organism makes a very weakly growth.

2. The same plus 2% cane sugar. In this the organism makes a poor growth as compared with beef broth, but the clouding is estimated to be twice as dense as in the simple Dunham's solution. This growth is of short duration, however, owing, probably, to development of acidity, which inhibits or even kills the organism.

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[6] For details as to composition of the various culture media used in our work and the relative development of the organisms on these media, see Vt. Sta. Rpt., 13: 314. (1900.)

3. Neutral beef broth; the standard medium used in our work and one upon which the organism makes a good growth.

4. The same plus 2% cane sugar; a medium in which the growth is more rapid than in plain broth.

5. Cooked carrot broths. Two kinds have been used:

(a) Those in which equal weights of pieces of fresh carrot roots and of water were cooked and sterilized together by the fractional process in the steamer,

(b) The same in which, after the first cooking in the steamer, the roots were crushed and the liquid expressed and filtered through several thicknesses of paper to remove all of the cell-wall substance, then this filtrate returned to the flask and sterilized in the steamer by the fractional process. Both of these have, except in certain cases discussed below, proved to be the best of cooked media for this organism.

6. Living vegetables. Fresh living roots of carrot and turnip are both quickly invaded and rotted by this organism, furnishing apparently ideal nutritive conditions. The expressed juice from such recently decayed vegetables[7] was used in comparison with the preceding broth cultures 1-5.

The results were in general determined by comparing on razor sections of carrot and turnip roots the cytolytic action of like solutions of the alcoholic precipitates obtained from the above culture liquids.

The sixth method, using fresh uncooked vegetable, has given the most active enzym product as well as the largest amount thereof. In comparison with beef broth, which yields on an average about 0.25% of dry precipitate (i. e. 0.5 g. of dry precipitate from a 200 c. c. broth culture), this expressed juice from decayed turnip after filtration through paper has yielded over 0.5% of a precipitate, a 5% aqueous solution of which caused the complete rotting of a razor section from a turnip in ten minutes, whereas a like solution of the precipitate from a beef broth culture required nearly two hours. Thus the former scheme not only gave twice as much precipitate but a solution thereof twelve times as active as was a like solution of the latter. Another comparison was made by immersing the section directly in the living cultures, i. e., in the expressed juice of decaying turnip and in beef broth cultures of the same age, viz., four days. Turnip sections so immersed were fully rotted in twenty-five minutes in the turnip juice, whereas fifty minutes was required to do this in the beef broth culture; in other words, the former was fully twice as active as was the latter. In other trials the difference was even more marked, the vegetable juice being three times as active as were the broth cultures.

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[7] These were, of course, so handled as to insure pure growths of the organism. This was most surely and satisfactorily done by taking several roots, washing thoroughly, soaking twenty minutes in 0.1% solution of corrosive sublimate, rinsing in sterile water, then with precautions against contamination removing the surface to a depth of 0.5 to 1 cm., cutting thick pieces from the interior tissues and laying in sterile petri dishes. Inoculations on the surface of these at temperature 20°-24° secured their decay in two to three days.

The precipitates from the cooked vegetable broths, (a) and (b) of the fifth group have behaved about alike, indicating that the presence or absence of cell-wall substance has no effect on enzym production. Where a good growth has occurred, somewhat more precipitate was secured than from beef broth, which approximated but did not quite equal in weight that from the living tissues in enzymic activity. Since these were not secured and tested at the same time it is not possible to make exact comparisons. We have not, however, found these cooked vegetable media uniformly satisfactory.[8] In some cases excellent growths have developed, in others but weakly ones. In the former, as already stated, active enzymic development occurred, in the latter very little, i.e., the enzymic development was directly proportional to the vigor of growth. The beef broth cultures have given less active enzyms than these vegetable media, as has been explained. We have, however, continued to use beef broth largely in our comparative studies for the reason that the enzymic activity is sufficient for those purposes and more reliance can be placed upon the uniformity of the medium. The addition of 2 per ct. sucrose leads to more vigorous growth of the organism, especially in the earlier stages before too great acidity developed, and it is significant that more of the precipitate and with more enzymic activity was developed in the sugar broth (medium No. 4) than in the plain broth (medium No. 3).

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[8] We have had some puzzling experiences with such cooked vegetable broths, both of carrot and turnip. In our earlier trials (1900–01) they proved satisfactory media. In later ones (1902–03) they were unsatisfactory, this organism and various other soft-rot organisms failing to make strong growths in them. We have been forced to attribute this to the development of inhibiting poisonous compounds as a result of the cooking. It is known that cooking at high temperatures in the autoclave may develop poisonous compounds in vegetable broths which will completely inhibit bacterial growths. Dr. F. G. Novy advises us that these are probably decomposition products of the carbohydrates. We have, therefore, never autoclaved such vegetable broths. but always sterilized by discontinuous cooking in the steamer. After experiencing the above troubles we tried cooking at still lower temperatures, in one case below 80% but the results were no more satisfactory. Thinking the difficulty might be in the glass ware, we used very carefully cleaned Jena glass flasks but this seemed to make no difference. These differences are not associated with any marked loss of pathogenicity or other changes that we could detect in the organism and we were forced to attribute them to variations in the vegetable used.

Thus companion cultures of these two media nine days old, of which the sugar broth showed an acid reaction (+4.2 per ct.) and the plain broth was practically neutral (+0.7 per ct.), were rendered 80 per ct. alcoholic. The sugar broth yielded 0.3 per ct. of dry precipitate, the plain broth 0.25 per ct. A comparison of these cultures on carrot sections showed the former to be twice as active as was the latter, *i. e.*, to soften a like section in one-half the time. A repetition with these two media, precipitating on the sixth day, gave similar differences but a little less marked. The Dunham peptone solution has proved a very poor medium whether with or without the addition of sugar. The alcoholic precipitate from such cultures seven days old (media Nos. 1 and 2 above) have shown scarcely appreciable enzym content.

In conclusion, then, we may note that there seems a perfect correlation between the rate and vigor of the growth of the organism and the amount of enzym developed, i. e., the more vigorous the growth the more the enzym; that the presence of cell wall substance had no appreciable effect on the amount of enzym developed; and that in beef broth cultures the addition of sugar, which favors growth, also increased the enzym production.

There is nothing whatever here, therefore, to indicate that this enzymic production is a starvation phenomenon, but rather to the contrary, since the more vigorous the growth the more the enzym; moreover, the addition of carbohydrate food (sugar) seemed to stimulate enzym production, whereas the presence or absence of cell wall tissue seemed without effect. This last fact suggests the idea that the organism makes little or no use for nutritive purposes of the wall substance which it dissolves.

THE AGE OF THE CULTURE.

The enzym content was compared in carrot broth cultures (grown at 20–22° C.) of the respective ages of one and a half, three, five, seven, and nine days. A rapid increase was found from a scarcely distinguishable activity in the precipitate from the one and a half days' growth to a large amount from that of five days, and a continued but slower increase to the strongest action from the oldest cultures, viz., nine days. It was noteworthy that the increased degree of enzymic activity in the precipitates from these carrot broth cultures was accompanied by a like increase in the degree of rottenness of the vegetable tissues in the culture flasks.[9]

With cultures made in beef broth grown at laboratory temperature the results were less marked than those just recorded for the carrot broths. The outcome in the series showing most positive differences is indicated herewith. Each culture consisted of 150 c.c. of broth neutral to phenolphthalein:

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[9] L. H. Jones, a student in our laboratory, working upon another (undetermined) species of soft-rot organism reached like conclusions. Thus he found that cultures in potato broth eight days old gave an enzym less than one-half as active as were similar cultures sixteen days old. While a 5% solution of the alcoholic precipitate from eight days' growth required twenty-five minutes to decompose a turnip section, like solutions from the sixteen days' growth rotted the sections in ten minutes. When the eight day culture flask was opened it was found that the potato blocks were not fully softened, but when the sixteen day flask was opened the blocks were completely rotten.

Culture No.	Age when tested.	Reaction	Amount of Precipitate.
1.............................	3 days	—2.2%	0.495 g.
2.............................	6 "	—1.0%	0.460 "
3.............................	9 "	—0.9%	0.474 "
4.............................	17 "	neutral	0.445 "

Like solutions (5 per ct.) of these precipitates tested on carrot sections showed all to contain the enzym, the activity of the solution increasing with the age of the culture. There was distinctly more in 2 than 1; the difference between 3 and 2 was very slight and that between 4 and 3 not great. Another similar series of cultures of ages four, six, nine and eighteen days respectively showed practically like enzym activities. The amount of enzym here, as in the trials with broths of different composition, seemed directly proportioned to the amount of growth. In carrot broths the growth is slower in starting than in beef broth and persists in its increase for a longer time. This slower start in comparison with beef broth is very likely due to the excess of organic acids present in the vegetable broth and to the further increase in acidity during the early development before the soluble carbohydrates are used up. In the neutral beef broth this inhibiting influence is not present and the bacterial development is at its height in about four or five days, as judged by the degree of cloudiness of the broth. Here, as in the preceding trials, there is no evidence that the enzym formation is a starvation phenomenon, but rather the reverse—viz., the more vigorous development is accompanied by more enzym production. Moreover, the enzym after its excretion into the broth appears to be a fairly stable compound, hence tends to accumulate with the age of the culture. R. E. Smith (1902) develops a theory of the parasitism of *Botrytis cinerea* somewhat at variance with Ward's idea that the enzym development is a starvation phenomenon, and more in accord with our own observations on this bacillus. Smith's conclusion is that the fungus in the absence of abundant food cannot develop the wall-dissolving enzym. It can, however, develop a toxin which kills the host tissues. He regards the initial penetration of the host tissues by spore tubes following this as merely mechanical. Later, having acquired "vital energy" as a result of higher nutriment, the production of the wall-dissolving enzym occurs and this aids in the subsequent spread of the fungus through the host tissues.

TEMPERATURE.

The optimum temperature for most rapid growth of *B. carotovorus* is in the neighborhood of 28° to 30° C., i. e., tubes will show clouding more quickly at this than at lower or higher temperatures. The presumption would seem to be that enzym production would be most active at this temperature, but our trials have shown otherwise. Where the enzymic activity of precipitates from broth cultures grown for eight days in the incubator at a constant temperature of 30° C. were tested in comparison with those grown at room temperature (18° to 22°), the latter have shown distinctly more enzym than those grown in the incubator. We can offer no satisfactory explanation for this. Possibly comparisons at an earlier stage, say at three days' growth, would have shown somewhat different results. It is also possible that the difference is due to less aeration in the flasks held at the constant incubator temperature than occurs in those at the frequently fluctuating room temperature. It is evident that this lack of aeration would have more inhibiting influence with the older growths than with the early clouding. The result convinced us that better enzym production could be had outside than inside the incubator, and since making these trials all our cultures have been carried at room temperatures.

RELATION OF VARIOUS CONDITIONS TO THE ACTIVITY OF THE ENZYM.

EFFECT OF LONG KEEPING.

It is difficult to measure and record the rate of activity of such an enzym with a sufficient degree of accuracy to make exact comparisons. We have not succeeded in doing this to our entire satisfaction. So far as we can judge, however, there is no loss where the dried enzym-containing precipitate is kept for months or even years. Thus two samples of precipitates prepared and carefully tested in May, 1901, were kept and again tested in May, 1903, when so far as we could judge their activity was as great as when prepared two years before.

Spieckermann (1902:166) states that the activity of the similarly dried enzym precipitate obtained from this kale-rot organism was undiminished after four months in the dry state.

RELATION OF TEMPERATURE TO ACTIVITY.

Temperature relations were studied, using solutions of the alcoholic precipitate from carrot broth cultures and testing them on carrot sections. It was found that the action was slight at 2° C., good at 22°, better at 32°, best at about 42°, inhibited somewhat at 48°, showed pronounced inhibition at 50° and was practically or entirely checked at 51° and above. For example, the action was nearly twice as rapid at 42° as at 22°; and at 32° it was practically midway in rate between the higher and the lower. The optimum lay between 40° and 45°. When such solutions were held at various temperatures up to 49° for an hour, either in the presence or the absence of carrot tissues the enzym was uninjured, i. e., they showed normal activity when the temperature was lowered again. If, however, the heating was carried to 51° or above for ten minutes, whether in the presence or absence of carrot tissues, little if any action ensued thereafter.

A comparison of these results using the precipitated enzym with those described earlier in this article where the original broth was used, shows that the points of inhibition and destruction were approximately ten degrees lower in the solutions of the precipitate.

It is interesting in this connection to recall (cf. Green 1901:448) that observations upon invertase have shown that it withstands a temperature higher by 25° C., when cane sugar, upon which it acts, is present than it does in its absence. A similar variation, though not so extreme, has been observed with several other enzyms. This suggests that, in general, an enzym may enter into such a relation, either with the substance upon which it acts or with some other compound associated with it in solution, that as a result it may receive some protection against the injurious action of heat or other deleterious agencies. It is, of course, possible that the enzym in the original broth is in such relation to some organic matter as to be thus protected, but our attempts to protect it by the presence of carrot tissues in these experiments were unsuccessful since, as stated above, it was destroyed at the same temperature whether in the presence or the absence of the carrot sections. It is to be noted, however, that we were working here with the alcoholic precipitate redissolved in water Woods (1899) has shown that the ozydizing enzyms of the maple leaf withstand higher temperature when in the juices of the plant than when in the presence of alcohol.

In comparison with our results it is interesting to note that Brown and Morris (1890) found 35°–40° C. an especially favorable temperature for the cytolytic enzym of germinating barley, whereas it became decidedly less energetic at 50° and was almost completely paralyzed at 60°.

EFFECTS OF ACIDS AND ALKALIES.

The organism as studied was found to be parasitic on various vegetables, all of which possess an acid cell sap. In the course of its development, however, it renders the sap alkaline. It appears of interest, therefore, in connection with the question of the parasitism of the organism to learn the relation of the reaction of the medium to the activity of the enzym. This was investigated, using the alcoholic precipitate obtained from carrot broth cultures. Solutions of this were made in distilled water containing additions of the chemicals under trial and their activity tested on razor sections of carrot. The strength of the acid and alkali solutions was in all cases determined by titration against phenolphthalein.

Alkali.—It was found that the presence of sodium hydroxide titrating —2% inhibited the reaction slightly, and that the inhibition increased with the further addition of the alkali up to —10%, where it was total.

Acids.[10] —A very slight addition of hydrochloric acid seemed favorable to the action of the enzym, a reaction of +0.5% being about the optimum. The difference between this and the neutral solution was, however, slight. When the reaction was +2.5% or above there was great inhibition and at +5% it was practically complete.

Various organic acids were tested also, the results in detail being as follows:

Acid.	Strength of titration.	Effect.
Oxalic..............	+0.8 percent.	retarded slightly.
“	+1.1 “	“ greatly.
“	+8.0 “	complete inhibition.
Acetic..............	+0.2 “	no effect.
“	+0.5 “	“ “
“	+1.0 “	retarded greatly.
“	+10.0 “	complete inhibition.
Formic..............	+0.15 “	no effect.
“	+0.4 “	“ “
“	+0.75 “	retarded greatly.
“	+7.5 “	complete inhibition.
Tartaric.............	+0.14 “	no effect.
“	+0.55 “	“ “ (possibly slight retarding).
“	+5.5 “	almost full inhibition.
Malic...............	+0.2 “	no effect.
“	+0.8 “	“ “
“	+8.0 “	almost full inhibition.
Citric...............	+0.2 “	no effect.
“	+0.8 “	“ “
“	+8.0 “	almost full inhibition.

From these results it will be seen that these organic acids in no case aided the action; that where the acidity, as shown by titration, was +0.5% and less they were practically without effect; that +1.0% and above distinctly inhibited in all cases where it was tried, and that from +5% to +10% led to complete inhibition. Here again it should be noted that even this large amount represents only a very mild degree of acidity, viz., 0.5% more or less by weight.

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[10] These acids were made up by weight and titration strength determined afterward. One per cent gravimetric solutions titrated respectively as follows: hydrochloric +50; acetic +20; tartaric +11; citric +15.5; malic +15.5; formic +15.

EFFECTS OF PLANT JUICES.

Inasmuch as in the cases of actual decay of vegetables the enzym must occur in solution in the cell sap, it is of interest to learn whether the normally acid sap tends to retard its action as do the organic acids mentioned above. Two series of trials were made to determine this. In the first the juice was expressed from living tissues of each, carrot, radish and ripe tomato. These were tested by adding to each, respectively, equal parts of a 5% aqueous solution of the precipitated enzym from a carrot broth culture. The result was, therefore, a 2.5% solution of the precipitate in half-strength vegetable juice. There was slight retardation in all cases in the rate of action as compared with solutions in distilled water, this being a little more pronounced in the case of the tomato. The test was repeated with the tomato juice by dissolving 5% of the precipitate directly in the juice, thus placing the enzym in the presence of the full degree of acidity. Here the retardation was considerable, estimated at nearly one-half, i. e., there was about as much action in fifteen minutes in a water solution as in one-half hour in the tomato juice solution.

Titration of these vegetable juices showed the acidity of the tomato to be +5%, of the carrot +2%, of the radish +0.75%.

THE EFFECTS OF OTHER BACTERIAL PRODUCTS.

As a result of his studies on the bacterial soft rot of the turnip due to *Pseudomonas destructans,* Potter (1900:451) suggested that oxalic acid produced by that organism may play some part in the destruction of the middle lamella and the separation of the cells. The above results show that neither oxalic acid nor any of the normal acids of the host tissues so function in the carrot rot organism. Indeed this organism produces no oxalic acid. It does, however, produce a small amount of some undetermined acid in the presence of carbohydrates. In order fully to determine whether this unknown organic acid or other products of the bacterial metabolism favor or retard the enzym action, broths of various kinds in which the organism has been grown were heated to 80° C. to sterilize them and to destroy their enzym content. Two parts of each of these, respectively, was then added to one part of a solution in water of the enzym-containing precipitate and the activity of this mixture was tested in comparison with a solution of like strength of the precipitate in pure water. More or less inhibition resulted in every case, as follows: Carrot broth, cultures twelve days old, reaction to litmus slightly alkaline, slight inhibition; beef broth, cultures seven days old, reaction to litmus slightly alkaline, marked inhibition; Dunham's peptone solution, cultures sixteen days old, reaction to litmus neutral, decided inhibition, estimated to be one-half as active as the solution in pure water; Dunham's peptone solution plus 2% sugar, cultures sixteen days old, reaction to litmus strongly acid, decided inhibition, so that the tissues tested in this solution were not more acted upon at the end of twenty hours than were those in the simple Dunham's solution at the end of two hours. There is no evidence here, therefore, that the products of the bacterial growth aid in the cytolytic action of this organism. On the contrary, the evidence is that they tend to inhibit it.

DIASTATIC ACTION.

Repeated trials by the most delicate methods we could devise have failed to reveal any diastatic action worthy of note. The only indication observed has been an extremely slow and slight tendency to the conversion of starch into amylodextrin, as shown by a gradual change in iodine reaction from a clear blue to slightly purplish tint. Starch granules are not eroded even in cultures on potatoes, nor is there any change in the iodine reaction of such raw potato tissues, nor of cooked potatoes when used as a culture medium, except the slight one toward the purplish tint just noted. More delicate tests were made by mixing 1% of the washed starch from potato or wheat flour with water, heating to the boiling point, allowing to settle nearly clear and then filtering off the supernatant liquid. In this way a very weak starch solution was secured, but one which gives a clear iodine reaction. Saliva added to this solution removes the last trace of starch in a few moments. Equal volumes of this starch solution added to a 5% solution of the enzym-containing alcoholic precipitate from a carrot broth culture of *B. carotovorus* underwent no change even after nine days' standing, other than the slight conversion toward amylodextrin noted above. The enzym-containing alcoholic precipitates from beef broth cultures were likewise inactive. In this respect, again, the carrot-rot organism differs from Potter's white-rot organism of turnip (1901) and agrees with Spieckermann's cabbage rot organism (1902).

Grüss and Reinitzer, as explained in detail later in this paper, have advocated the idea that the cytolytic action of barley malt is simply due to diastase and hold that no "cytase" as distinct from diastase occurs in such extract. Newcombe's work (1899:81) shows the incorrectness of their conclusions as regards malt extract, and we are convinced from our experiments that in this soft-rot organism we have an enzym different from diastase.

THE ACTION OF THE ENZYM ON THE HOST PLANT TISSUES.

THE COMPOSITION AND ORIGIN OF THE MIDDLE LAMELLA.

Inasmuch as the action of this enzym is chiefly upon the middle lamella of the host cells, it will make the subsequent discussion of this matter clearer if we briefly review the facts as at present understood relating to the composition and origin of this portion of the cell membrane. Fortunately, some excellent work along this line has been done within recent years.[11]

Examination of any mature parenchymatous cell, as of carrot or turnip root, shows the middle lamella as a more or less clearly defined refractive line through the middle plane of the cell walls. On either side, i. e., lying between this and the cell cavity is an inner lamella, or, as Allen calls it, "primary wall." Where three or more cells meet in mature tissue intercellulars commonly occur and often slits or openings radiate from these for some distance. These result from mechanical strains, doubtless caused by growth changes.

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[11] See critical reviews of the subject by Green (1901:298–300) and Allen (1902).

Where such openings occur it is usually evident that the middle lamella substance has split along its middle plane and a brightly refractive border line of this substance bounds each inner lamella externally along these intercellular slits and spaces. In many cases, however, no such intercellular has developed and the middle lamella substance extends as an apparently homogeneous layer of slightly varying thickness between the adjacent inner lamellae of the walls. At the junction of three or more cells this expands into an angular mass, completely filling the space formed by the meeting of their rounded contour lines. As seen in section these masses are most often triangular. There is some evidence from their deeper staining properties that these are denser than the thinner lamellar plates, and our observations on the rate of solution, to be discussed later, are in accord with this idea.

Various opinions have been held as to the composition and origin of the middle and inner lamellae of the walls. It has long been understood that parenchymatous walls of the kind under discussion are composed of cellulose. More recently it has been shown that "cellulose" includes a group of closely related compounds. Moreover, if cellulose stains or solvents be applied to parenchymatous tissues it will appear that the inner lamellae are fundamentally cellulose, whereas the middle lamella does not give the cellulose reactions. More critical observations will show that the inner lamellae are rarely if ever homogenous but also contain substances other than cellulose.

Cross and Bevan (1895:78, 89) in their discussion of celluloses make two groups, (1) the cellulose group, (2) the compound celluloses. They further sub-divide the cellulose group into three sub-groups:

(a) Resistant to hydrolysis, e. g., cotton.

(b) Less resistant to hydrolysis, found in grass stems, etc.

(c) Low resistance to hydrolysis, found especially in fleshy roots and in seeds.

They term groups (a) and (b) the celluloses proper. Group (c) is held to be quite different from these, but for convenience of treatment they allow it to remain in the larger group, accepting Schultze's name as satisfactory, viz., pseudo-cellulose or hemicellulose. As defined more exactly the hemicelluloses are "substances closely resembling in appearance the true celluloses but easily resolved into simpler carbohydrates by the hydrolytic action of enzym or of the dilute acids or alkalis."

We are, however, chiefly concerned with the compound celluloses which Cross and Bevan term "pecto-celluloses," since these constitute the middle lamella and other wall elements acted upon by the carrot-rot enzym. The present understanding of these dates from the work of Fremy (1840, 1848), who found in plant cell walls, along with cellulose, another substance which he called pectose. He also isolated from carrot roots and other plant tissues an enzym "pectase" capable of gelatinizing this pectose and related compounds, which will be discussed in more detail later. Subsequently chemists have confirmed Fremy's observations and conclusions and class the pectose series of compounds with the celluloses as indicated in the discussion above from Cross and Bevan. Mangin has recently (1888–1893) made most extensive studies upon these matters and shows that here again we have not a simple compound but a complex of closely related compounds. These he divides into two natural series, the one neutral, the other acid. Pectose is one of the less soluble neutral series, and pectine is a more soluble form. Both of these are of wide distribution, especially in the walls of young tissues. Of the acid series pectic acid is of common occurrence and peculiar interest to us and especially its insoluble salt calcium pectate. Fremy supposed that when his enzym, pectase, clotted the pectose solutions it did so by converting the pectose into pectic acid. Bertrand and Mallevre (1894, 1895) have recently shown that this clot is, however, calcium pectate. Payen[12] believed that the middle lamella consists largely if not wholly of this salt, and the recent studies of Mangin and Bertrand-Mallevre have confirmed this belief. Moreover, these recent studies have shown that the inner lamellae contain varying proportions of pectose or pectic compounds intermingled with the celluloses. The relation of these is evidenced if Schweitzer's reagent, which is a cellulose solvent, be carefully applied, when it will remove the cellulose and leave the pectic skeleton. The converse occurs, as will be shown in detail later, when the carrot-rot enzym acts upon the walls, removing the pectic elements and leaving the cellulose.

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[12] Cf. Green 1901:248.

Mangin's studies led him to conclude that in the early stages of its development the wall consists more largely of the less soluble pectose, whereas in the mature wall the calcium pectate predominates in the original plane, i. e., the middle lamella, and the pectose which occurs is in the inner lamellae, i. e., nearer the cytoplasmic layers. The proportion of cellulose becomes increasingly predominant, however, as one passes from the middle to the inner layers. Although this is the case, there probably occurs, even in the young walls, a thin sheet of calcium pectate invisible under the microscope but evidenced by the splitting of the walls along the middle plane under the action of pectate solvents. With the increasing age of the cell this layer is thickened and more clearly defined until it becomes plainly visible in the mature cell as the middle lamella. The splitting of the lamella along the median plane as a result of the tensions set up between the growing cells indicates that this apparently homogeneous plate is in reality from the beginning a double sheet, one-half of which originated with each daughter cell following mitosis.

Fremy's enzym, pectase, which is especially abundant in growing tissues, is supposed to function[13] in this lamella formation by converting the insoluble neutral pectose of the inner lamellae into the more soluble pectine and ultimately into pectic acid, which then passing, perhaps by diffusion pressure, to the outer surfaces of the inner lamellae, i. e., to the planes where this meets the middle lamella layers, is there combined with calcium to increase this middle lamella substance. This appears homogeneous, but as will appear later is, like the inner lamella, distinctly stratified in structure, at least in the heavier parts at the angles.

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[13] Cf. Green. 1901:297–300.

This conception involves the idea of the passage in the growing walls of the pectose substances by gradual filtration through the cellulose layers from the protoplast where they originate toward the exterior, and is at the same time in accord with the idea of Allen (1902:31) that the young cambium wall really forms the basis of the middle lamella of the older tissues.

THE ACTION OF THE ENZYM ON THE CELL-WALL.

The rapidity of the invasion of vegetable tissues by the carrot rot organism was discussed in our earlier report (1900:307–312). As there explained it rots only parenchymatous tissues. The invaded tissues become watery and usually more or less darkened in color when exposed to the air. The cells rapidly lose all coherence and always show a sharply defined line of demarkation, indicating that the softening occurs quickly and completely after it begins. Examination of such recently decomposed tissues under the miscroscope shows the cells to be already isolated or easily separable along the plane of the middle lamella. The protoplasmic sac within the cell is collapsed, more coarsely granulated than normally, and evidently dead and in the process of disorganization. Bacteria teem around and between these cells but are so rarely seen within them that where this does occasionally occur, one is led to attribute it to mechanical rupture of the softened walls rather than to direct solution. (See figures 1, 5 and 6.)

In the case of the inoculation of a cut surface of root kept in ordinarily dry atmosphere, the invaded area dries out very rapidly; if, however, it is kept in a saturated atmosphere gray drops of exudate teeming with bacteria form on the surface and the tissues underneath become sunken. It is evident, therefore, that among the products of the bacterial growth are active osmotic substances which draw the water, and of course soluble nutritive matters, from the dying or dead protoplasts. The organism is powerless to invade wilting or pithy and partially dried-out vegetable tissues of even the most susceptible varieties, such as turnip, radish and carrot. These facts, with others to be set forth later, show its active invasion to occur in the intercellular spaces and along the planes of the middle lamellae. A fundamental condition of this invasion is an abundant moisture content in the host tissues, the more the better, apparently. The water-logged, or translucent appearance of the invaded tissues is doubtless due in part to the expulsion of gas incident to the filling of the intercellulars with liquid resulting from the plasmolysis of the cells, and in part to the changes in the optical characters of the walls themselves. The fresh walls are uniformly refractive throughout with a slight difference between the middle and the inner lamellae. Almost immediately following their immersion in either a living culture or an aqueous solution of the precipitated enzym the inner lamellae begin to lose their refractiveness. This change in appearance is evident even to the unaided eye if thin sections are closely observed. It is more rapidly followed under the microscope, and is then seen to be associated with a swelling of the primary wall or inner lamellae, sometimes to twice their original thickness, and with the appearance within a short time of a delicate laminated structure in these swollen walls, as shown in the accompanying figures. The middle lamellae

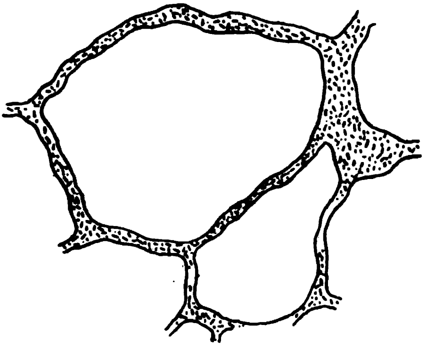

FIG. 5. A sterile block cut from living carrot root was immersed for 20 hours in a broth culture of *B. carotovorus*, then fixed in hot absolute alcohol, imbedded in paraffin and sectioned. The above sketch (x 250) shows a large thin-walled parenchyma cell lying about three cells inward from the surface. The enzymic action was here complete, the cells isolated and the intercellular spaces gorged with bacteria, but the undissolved remnant of the wall kept them from invading the cell cavities.

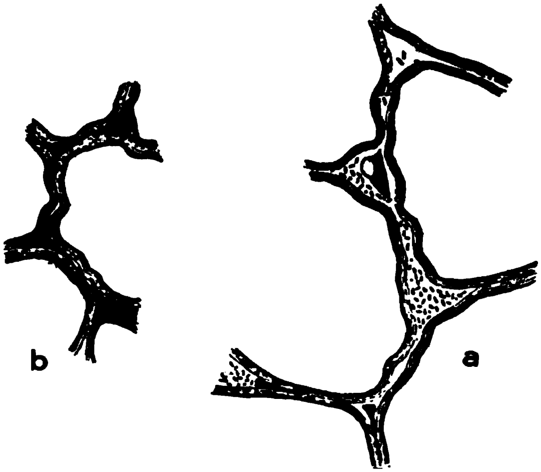

FIG. 6. From deeper lying portions of the same sections as Fig. 5. (x 375). The cells here were smaller and thicker walled. In a the bacteria were abundant in the intercellulars and the middle lamellae partially dissolved; b, from a little deeper, showed less advanced action, the walls swollen and laminated but still cohering.

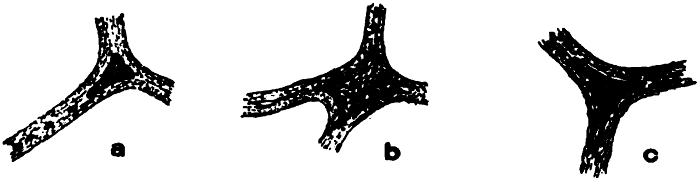

FIG. 7. Cell membranes from the central part of the same sections (x 500). The earliest stages of bacterial invasion along the plane of the middle lamellae are shown in a and b, while c shows the action upon the walls in advance of invasion. The laminated structure appears both in the swollen inner lamellae and in the undissolved portions of the middle lamellae which occur at the angles of the cells.

also become less refractive, though not softly translucent, as do these adjacent inner layers, and soon begin to melt away in the thinner portions. The middle lamellar substances, as already explained, usually form thicker masses at the angles of the cells, often triangular as seen in optical section. As the thinner parts dissolve, these heavier portions remain isolated. There are now distinct openings between the adjacent cells in most places and the swelling of the walls has reached its maximum. Tapping on the cover glass, tearing with needle point or other mechanical test, will show that the cells have lost all cohesion, that is, that the tissues are fully "rotten." Thin razor sections of carrot or turnip placed in living cultures or in active enzym solutions pass through these changes in from ten minutes to an hour, although longer immersion may be necessary to secure the complete solution of the thickest pieces of intercellular substance. Meanwhile there is a slight thinning of the walls proper from without inwards, i. e., from the lamellar side towards the cell cavity, but this is not great and complete solution has never been observed either in the presence of the living organisms or in solutions of the enzym. In order to determine this matter to our satisfaction the same sections have been kept under observation for three weeks, with repeated measurements and camera drawings during this period, but there was little change after the first few hours. Cellulose stains (iodine and sulphuric acid or chlor-zinc-iodine) give clear blue reactions with these fully softened walls, and this reaction is the same even after the longest immersion. The lamination of the walls becomes increasingly apparent for a short time, after which there is no further change.

In no case have we found evidence of any action whatsoever upon lignified or cuticularized walls. Vessels lie for days or weeks in the presence of the enzym with the walls unchanged in refractive character or other appearance or in staining reaction to phloroglucin.

In order to follow the course of invasion more carefully blocks of fresh carrot tissue cut from near the core, with precautions to insure sterility, have been immersed in broth culture tubes of *B. carotovorus* and at varying periods of time after the surface tissues had begun to show decomposition they have been carefully transferred to absolute alcohol to kill and fix the organisms in place, then imbedded in paraffin and sections cut three to twelve microns in thickness. For differentiating the wall tissues and organisms various stains have been tried, including Ziehl's carbol-fuchsin and aqueous solutions of Congo red, ruthenium red and methylene blue.

The best results were obtained from the use of ruthenium red and methylene blue. It was found that about two minutes' immersion in each of these in turn, followed by brief washing in alcohol, gave slides showing excellent differential staining. The organisms, the unaltered walls and the undissolved remains of the middle lamellae retained the blue color and in the walls which had been fully acted upon the red color predominated. Examinations of slides so stained have shown very interesting conditions. The Congo red also clearly reveals the solvent action, staining deeply the unaltered walls and giving but faint color to those from which the soluble part has been removed. The line of demarkation between such deep and faint staining tissue is very abrupt, indicating that the solvent action is rapid and complete after the penetration of the active substance. This action occurs some ten cells, more or less, in advance of the invasion of the organism. It is evident that the chemical agent causing this change penetrates the tissues and completes its action considerably in advance of the invasion of the organism. The rate of the invasion was clearly dependent upon the nature of the walls and the form of the cells. As already stated, no action occurs on cuticularized or lignified walls. Where the cells were much elongated in one direction the action progressed more rapidly in the direction of their longer axis. The organisms in the more recently invaded portions were chiefly found in the larger intercellular spaces at the angles of the cells. From these they made their way, evidently along the planes of the dissolved lamellae, occurring in the narrower portions as a single line of rods lying end to end. In no case were they within the cell cavities, although they often crowded the lumina of the open vessels. The walls themselves showed in these stained sections the same transitions noted in the fresh material, viz., swelling, and evident lamination of the inner lamellae preceding the full solution of the middle lamella. The middle lamellar substance itself, especially at the angles of the cells where it occurred in larger masses, showed distinctly a laminated or fibrillar structure when partially acted upon, indicating that it, like the wall, is not of entirely homogeneous structure.

The discussion thus far has been based upon observations made upon carrot tissues. Studies of the invasion of turnip and radish roots and cabbage petioles have shown practically similar conditions. The rate of softening of sections of these tissues in solutions of the enzym-containing precipitate and in living cultures has proved to be more rapid in the turnip, radish and cabbage tissues than in those of the carrot. In the latter the action was faster on the core than on the cortex tissues. It was more rapid in the young potato than in the mature tuber. On the beet root no action whatever occurred.

In order to secure data for the above conclusions careful trials were made on two occasions with a 5% solution of an alcoholic precipitate containing a not very active enzym. This weaker enzym, acting more slowly, permitted more satisfactory differentiation between the rate of softening of tissue of similar susceptibility. The trials were made about July, using vegetables fresh from the garden except for the potatoes of Series I. The details are as follows:

Series I. Using thick razor sections of (1) old potato, core; (2) young carrot, a. core, b. cortex; (3) young radish, core; (4) young turnip, core; (5) cross sections of young cabbage petiole. The interval before complete disintegration was: turnip, forty minutes; radish and cabbage, about forty-five minutes; carrot core, eighty minutes; carrot cortex, ninety minutes; potato, one hundred minutes.

Series II. Using similar solutions and vegetable sections, except that sections from a young potato tuber fresh from the garden were substituted for the old potato (1), and the following were added: (6) cotyledon of pea, approaching maturity; (7) root of beet. The intervals before complete disintegration were: turnip, radish, cabbage (about alike), thirty-five minutes; young potato, carrot core (about alike), eighty minutes; carrot cortex, pea (about alike), one hundred minutes; beet, limp but no signs of disintegration even after twenty-four hours' immersion.

These observations as to the rate of action of the enzym on plant tissues clearly accord with the results from inoculations into the corresponding vegetables made in our earlier studies (1900:307) and indicate, what we would expect, that aside from moisture relations the relative susceptibility or resistance of the host plants to infection depends largely, if not wholly, upon the composition of the middle lamellae.

A COMPARISON OF THE ENZYM PRODUCED BY BACILLUS CAROTOVORUS, WITH CYTOLYTIC ENZYMS FROM OTHER SOURCES.

CYTOLYTIC ACTION BY SOFT-ROT BACTERIA FROM OTHER SOURCES.

In the course of these studies upon the cytolytic enzym of the carrot-rot bacillus comparisons have been made with the various other strains of soft rot organisms described in Part I of this bulletin, p. 258. In order to make this clear we will summarize the list, which includes 45 strains, as follows:

Three strains of cabbage-rot bacilli isolated in Vermont by F. R. Pember in 1899.

Twenty-three other strains of cabbage-rot bacilli isolated in Vermont by W. J. Morse in 1901.

One strain of turnip-rot bacillus isolated by L. P. Sprague in Vermont, 1903.

Twelve strains of soft-rot bacilli secured by Harding and Stewart in New York, of which one was associated with the soft rot of *Amorphophallus simlense* and the other eleven were from the soft rot of cabbage.

Six other soft-rot organisms from various sources, as follows: Townsend's calla rot, *Bacillus aroideae;* Harrison's cauliflower rot, *Bacillus olereaceae;* van Hall's two iris-rot organisms, *Bacillus omnivorus* and *Pseudomonas iridis;* Spieckermann's kale-rot organism (*Bacillus*), and Potter's turnip-rot organism, of which the strain we had was also a *Bacillus*.

Forty of these forty-five strains, with three others, were studied* in detail by Messrs. Harding and Morse, the details

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*Their studies did not include the following: Pember's R., *Pseudomonas iridis*, nor the New York organisms O. 1 II 6 c, O. 1 II 6 a, and the bacillus from Amorphophallus.

of their studies being related in Part I of this bulletin. It will suffice here to say that their comparative studies as there recorded lead them to conclude (p. 287) that these forty strains probably constitute only one somewhat variable species. The following comparisons as to enzym production were, however, completed before their decision was reached and we believe they were worth recording partly as contributing further evidence as to the general likeness of these strains and partly as emphasizing the minor variations which we believe must always be expected to occur with different bacterial strains, even of the same (so-called) species.

The comparisons as to enzym production have been made by testing both the living cultures and the alcoholic precipitates, following the general methods outlined earlier in this article. Inasmuch as the alcoholic precipitate yields the enzym in a more concentrated form, and one in which it can be preserved indefinitely for comparative trials, this method has been chiefly relied upon. In all cases much care has been exercised to insure uniformity in the several series as to medium and cultural conditions. The trials of cytolytic activity were made on razor sections of vegetables, carefully selected for uniformity, and the trials repeated until convincing evidence was obtained as to relative activity. Inasmuch as it was not practicable, for obvious reasons, to make close comparison of more than a limited number of these at a time, they were handled in series of six or eight in a group. Since there was some variation in the vegetable upon which the test was made in different cases it is to be noted that *B. carotovorus* of the original strain, or some other organism whose activity was well known, was included in each series. In all cases except Pember's organism R cytolytic action occurred. In order to have a basis for comparison the organisms of each series were grouped in order of cytolytic activity into three classes, as follows:

Class I. Activity moderate, *B. carotovorus* being the standard of this class.

Class II. More active than I, intermediate between I and III.

Class III. Most active, Vermont XLVIII and Turnip Rot D well representing this class.

The following tables give the results of the trials grouping the various organisms in these classes according to cytolytic activity.

SERIES I. EIGHT DAYS' GROWTH; CULTURAL CHARACTERS ALIKE IN ALL; CYTOLYTIC ACTION TESTED ON CARROT AND CABBAGE.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
Calla rot (B. aroideae)[14]	1%	.465 gr.	111.	0.
Pember A...........	1%	.254 "	111.	
" R...........	1%	.532 "	0.	
Vermont XXXIII....	1%	.344 "	11.	
" XLVIII....	1%	.370 "	111.	
B. carotovorus.......	1%	.467 "	1.	0.

[14] In some other trials Calla rot has proved about like *B. carotovorus* in enzymic activity.

SERIES II. NINE DAYS' GROWTH; CULTURAL CHARACTERS ALIKE IN ALL; CYTOLYTIC ACTION TESTED ON RADISH.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
Pember A...........	1.1%	.355 gr.	111.	0.
Vermont XLVIII....	1.4%	.374 "	11.	0.
" LI....	1.3%	.391 "	1.	0.
" LIV....	1.4%	.393 "	11.	0.
" LVI....	1.2%	.434 "	1.	0.
" XCIV....	1.3%	.366 "	1.	0.
" XCVII....	1.1%	.293 "	111.	0.
" CII....	1.4%	.260 "	11.	0.

SERIES III. SEVEN DAYS' GROWTH; CULTURAL CHARACTERS ALIKE IN ALL; EXCEPT THAT MORSE'S 98 SHOWED LESS AND PEMBER'S 2 HEAVIER CLOUDING THAN THE REST; CYTOLYTIC ACTION TESTED ON RADISH AND TURNIP.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
Vermont XXV....	1.%	.300 gr.	11.	0.
" XXIX....	1.%	.241 "	11.	0.
" XXXI....	1.1%	.241 "	1.	0.
" XXXIII....	0.7%	.344 "	11.	0.
" XCVIII....	0.9%	.275 "	11.	0.
" CIII....	1.%	.185 "	11.	0.
Pember C...........	0.8%	.366 "	111.	0.
" R...........	1.3%	.350 "	0.	0.

SERIES IV. SEVEN DAYS' GROWTH; CULTURAL CHARACTERS ALIKE IN ALL: CYCTOLYTIC ACTIVITY TESTED ON TURNIP AND RADISH.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
Vermont XLVIII....	1.1%	0.315 gr.	111.	0.
" XLIX....	1.2%	0.335 "	11.	0.
" L....	0.8%	0.386 "	11.	0.
" LII....	0.4%	0.230 "	111.	0.
" LV....	1.%	0.317 "	1.	0.
" XCV....	2.%	0.304 "	111.	0.
" XCVI....	1.2%	0.300 "	11.	0.
" XXVI....	1.2%	0.303 "	11.	0.

SERIES V. SEVEN DAYS' GROWTH; CULTURAL CHARACTERS ALIKE IN ALL; CYTOLYTIC ACTIVITY TESTED ON TURNIP AND RADISH. (VERMONT XLVIII FROM SERIES IV WAS INCLUDED IN HERE AS A CONTROL.)

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
Vermont C...........	1.3%	0.334 gr.	11.	0.
" CI...........	1.2%	0.238 "	111.	0.
New York, 0.2 e.......	1.2%	0.410 "	1.	0.
" Miller, 3 No. 2	0.9%	0.380 "	111.	0.
" 0. R. Be.....	1.%	0.334 "	1.	0.
" Miller 2, No. 2	0.9%	0.252 "	11.	0.
" 0. R. Bi.....	1.2%	0.400 "	111.	0.
" 0.1 II 6 c....	1.%	0.440 "	11.	0.
Vermont XLVIII......	1.1%	0.315 "	111.	0.

SERIES VI. SEVEN DAYS' GROWTH; CULTURAL CHARACTERS ALIKE EXCEPT GENEVA 10 WHICH SHOWED HEAVIER CLOUDING AND PELLICLE; ENZYMIC ACTIVITY TESTED ON TURNIP AND RADISH.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
New York, Miller 3, 3....	1.3%	0.361 gr.	1.	0.
" Miller 3, 1...	1.5%	0.240 "	11.	0.
" Riverhead 3, 1	1.7%	0.250 "	11.	0.
" 0.1 II 6a....	1.3%	0.134 "	1.	0.
" 0.2 f........	1.5%	0.264 "	111.	0.
" Riverhead 2, 1	1.8%	0.237 "	11.	0.
Vermont XLVIII......	1.5%	0.258 "	111.	0.

SERIES VII. SEVEN DAYS' GROWTH; CULTURES SIMILAR IN VIGOR AND GENERAL APPEARANCE; TESTED ON TURNIP.

Organism.	Reaction.	Weight of Precipitate.	Cytolytic activity.	Diastatic activity.
B. carotovorus.........	1.4%	0.689 gr.	1.	0.
Kale rot (Spieckermann)	2.%	0.626 "	111.	0.
Turnip Rot D.........	1.8%	0.674 "	111.	0.
B. olereaceae..........	1.7%	0.350 "	1.	0.
B. omnivorus.........	1.8%	0.435 "	11.	0.
Potter's bacillus........	2.%	0.676 "	11.	0.

These results are in general accord with those of preceding investigators so far as published.

Potter describes (1899, 1900) for his *Pseudomonas destructans* action upon the wall like that we have observed for *B. carotovorus*. He records later (1902:393) evidence of direct penetration of the softened cellulose remnant of the wall by the organism. This is probably to be regarded as due to physical pressure rather than to solution of membrane, though it is so interesting and important a thing that it is to be hoped that further confirmatory evidence may be adduced. Potter also records diastatic action by this organism. In comparing our results with his it is to be borne in mind that the organism we have in culture is probably not his original organism, since this is a *Bacillus* instead of a *Pseudomonas*.

Spieckermann (1902) describes in detail cytolytic action by his organism identical with that observed by us, and absence of diastatic action.

Van Hall (1903) likewise describes in detail cytolytic action stopping short of complete solution of the cellulose wall and absence of diastase action by *Bacillus omnivorus*.

Harrison (1902) has attributed solution of the middle lamella to the organisms described by him.

We are therefore convinced that in all of these cases, including the forty-five strains of organisms from different sources, there is developed the same middle-lamella-dissolving enzym as in *B. carotovorus*, and that moreover in all cases alike there is neither complete solution of the cellulose elements of the wall nor diastatic action.

CYTOLYTIC ACTION AS RECORDED FOR OTHER BACTERIA.

The fact that the softening and solution of plant cell walls result from certain bacterial growths has been known for many years.

Mitscherlich in 1850 observed the destruction of cell walls and consequent liberation of starch when potatoes decompose in water, and believed it due to the vibriones which develop in the liquid.

Van Tieghem (1879) studied the decomposition of various vegetable tissues. He considered this due to the action of a single polymorphous species of *Bacillus* to which he gave the specific name *amylobacter*. He found that these organisms could decompose only the younger or less resistant tissues. Old tissues and those lignified, cuticularized, or suberized were resistant to the action as also was the cellulose of bast fibres.

De Bary (1887:101) accepted van Tieghem's account of the breaking up of cellulose membranes by a "diastatic enzym" in the process of decay attributed to *Bacillus amylobacter*. It is, however, generally agreed by bacteriologists to-day that this name is applicable to a class of bacteria rather than to any single species.

Vignal (1889) in his monograph on *Bacillus mesentericus vulgatus* records that it secretes a ferment capable of dissociating the cells of potato tubers by dissolving the intercellular substance, i. e., middle lamella, but without dissolving the cellulose of the wall. Similar action occurred upon parenchymatous tissues of beans, chestnuts, turnip, carrot, cabbage, beets and numerous young stems when these were immersed in the cultures. In none of these did full solution of the cellulose walls occur even after three months. It is noteworthy that this organism at the same time developed several other enzyms, viz., diastase, a proteolytic enzym, and a rennet, and that the cellulose remnant of the wall persisted in the presence of all of these.

Heinz (1889) observed a similar disorganization of the tissues of hyacinth as a result of the invasion of the tissues by the organism he describes as *Bacillus hyacinthus septicus*. It is noteworthy that he found this organism incapable of liquefying gelatin, in which it differs from the carrot-rot organism.

Van Senus (1890) observed the solution of fibrous and parenchymatous plant tissues by bacteria. He attributes the action to *B. amylobacter* and a smaller kind acting conjointly, neither alone accomplishing it. His methods have been considered by later investigators too crude to insure reliable results.[15]

Kramer (1891) isolated from decaying potatoes an aerobic spore-forming bacillus capable of dissolving the intercellular substance of potato tissue, and of attacking the cellulose membrane also.

Frank (1899) found dissociation of the cells of potato as a result of the invasion of *Micrococcus phytophthorus*. The action of this organism likewise stopped short of the solution of the cellulose layers, removing only the middle lamella, and also left the starch grains intact.

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[15] Cf. Omelianski, 1902:200.

Wehmer (1898) studied the bacteria concerned with the rotting of potatoes, all of which he regarded as of saprophytic nature. He found two types of decomposition to occur, associated with different organisms. In the first, "breifäule," the middle lamellae only are dissolved. He considers that the acid produced by the bacteria may be the agent in this solution of the pectic compounds, rather than an enzym. In the second, "schleimfäule," there is ultimately solution of the entire wall substance.

Laurent (1899) working with *Bacillus coli communis* found that, although normally a saphrophyte as concerns plant tissues, yet when inoculated into weakened vegetables it developed there and in so doing acquired virulence as a parasite upon potatoes of full vigor, and also upon turnip and onion. There was no secretion of diastase (amylase). Heating the culture to 62° C. for five minutes destroyed this ferment.

Lepoutre (1902), continuing Laurent's work by similar methods, developed strains pathogenic to plant tissues of three other species of bacteria, normally saprophytic, viz., *Bacillus fluorescens liquefaciens*, *B. mycoides* and *B. mesentericus*. The first acted like *B. coli communis* in Laurent's cultures, viz., dissolved the middle lamella, but not the cellulose or the starch. Lepoutre considered the solution of the lamella due to an enzym which he speaks of as a variety of pectinase, evidently accepting the name suggested by Bourquelot and Herissey (see discussion later in this paper).

Migula (1900:529) states that the culture of his *Bacillus asterosporus* upon slices of cooked carrot leads to the solution of the middle lamella.

Winogradsky (1895) studied the retting process of flax and considered it due to a single specific anaerobic bacillus. He concluded that this fermented the pectin elements readily but was without influence on cellulose proper, e. g., Swedish filter paper. This conclusion is in accord with the opinion expressed by Kolb (1868) that the retting process is essentially a pectic fermentation.

Behrens (1902) studied further the organisms concerned with the different methods of flax retting. He found that in all cases alike the essential thing is the solution of the middle lamellae of the parenchyma cells. He concluded that in the latter process a specific anaerobic bacillus is the agent, while in other processes fungi (Mucors) take the active part.

Haumann (1902) studied the flora of retting flax and concluded that there are numerous species of bacteria and fungi active in the process. He found several of these species capable of liquefying calcium pectate.

Doubtless further search would reveal other records of the solution of the middle lamella without evidence of the solution of the cellulose layers. It may safely be inferred, in our judgment, that the action in most of these cases was like that in the soft-rot organisms studied in our laboratory. These citations will at least suffice to emphasize the point that such action on middle lamellae apart from action on cellulose is a common occurrence in bacterial fermentation. It must not be concluded, however, that cytolytic action by bacteria is confined to the middle lamella and like parts of the wall. While this is the action concerning which we have the most detailed evidence, proof is not lacking that there are bacteria capable of causing the full solution of parenchyma walls, and even of the more resistant cellulose of fibre.

E. F. Smith (1903) has shown this in his painstaking work upon the black rot of the cabbage caused by *Pseudomonas campestris*.

No other equally convincing evidence has come to our attention as to like action by bacteria parasitic upon plants. We have no doubt, however, that such cases will be found not infrequently as bacterial plant diseases are more fully investigated.

Omelianski (1895) began in 1894 a study of the solution of normal or typical cellulose as represented by Swedish filter paper. The final summation (1902) of his painstaking work shows that at least two species of bacteria are capable of causing the complete solution of this most resistant cellulose. He believes that further study will reveal other such organisms. He considers that in the so-called "cellulose-fermentation," earlier writers were dealing chiefly or wholly with the more easily hydrolyzable celluloses and pectic compounds.

CYTOLYTIC ACTION OF CERTAIN FUNGI.

Although it has long been known that fungi penetrate cell walls, de Bary (1886) first separated a cytolytic enzym from the living fungus and studied its characters and action. He thus proved that *Peziza sclerotiorum* (*Sclerotina libertiana*) secretes a soluble ferment which causes some swelling of the walls of vegetables invaded by it, followed by a solution of the middle lamella and consequent isolation of the cells. He observed a partial solution of the inner lamellae, and the residual portion gave a beautiful cellulose reaction with chlor-zinc-iodide.

Ward two years later (1888) did his painstaking work on the lily *Botrytis*. Here he found an enzym which causes a swelling and lamination of the inner and solution of the middle lamella of the cell walls of the host plant. He considered it "extremely probable this ferment is of the same nature as the one extracted by de Bary." Ward also observed the extension of cytolytic enzym drops from the tips of the *Botrytis* hyphae, which he considered to be associated with the hyphal growth.

Arthur (1897:499) records similar lateral exudations upon the young hyphae of *Rhizopus,* which he believes to be associated with the local secretion of cytohydrolytic enzym.

Laurent (1899) in subsequent studies upon the *Sclerotinia* enzym found it to be destroyed by heating to 54° C. when in solution, whereas it required 62° C. to destroy the middle lamella dissolving enzym of *Bacillus coli communis.* He concludes from this that these enzyms must be different. His argument is less convincing from the fact that his two enzyms were secured from cultures made on different vegetable media, viz., artichoke in one case and potato in the other. There may have been by-products from the *Sclerotinia* culture which lowered its resistance. The fact was referred to, earlier in this paper, that Green (1901:448) and others have recorded much wider differences, under varying conditions, in the thermal destruction point of certain other enzyms. This must at least make one cautious in accepting conclusions drawn from such evidence.

Kissling (1889) studied the pathogenic action of *Botrytis cinerea* and found that it formed a poison which kills the protoplasm of the invaded tissues, and which he thought enzymic and the same as the ferment secured by de Bary from Peziza. Kissling did not, however, differentiate between the two changes which occur, viz., the death of the protoplasm and the dissociation of the cells.

Kean (1890) showed that the decay of sweet potatoes and other vegetables as a result of the invasion of *Rhizopus nigricans* (*Mucor stolonifer*) is due to an enzym which softens the tissues, but he does not give the details of the changes as secured under the microscope. He found a similar softening by the juice expressed from potato leaves infested with *Phytophthora infestans,* also from a *Botrytis* growing on stone crop (*Sedum*).

Miyoshi (1895) observed the penetration of the walls of different plants by *Botrytis* and *Penicillium* and inferred the presence of an enzym, but did not isolate it.

Behrens (1898) published the results of his extensive studies upon the pathogenic action of *Botrytis vulgaris* (*B. cinerea*)[16] upon fruits and clearly distinguished between the toxic and cytolytic action. He showed that there is a toxin developed which is not destroyed by boiling, thus confirming de Bary's observations, and in addition an enzym or enzyms which acted like de Bary's in causing dissociation of the cells. He found enzymic action from *Penicillium glaucum* and *P. luteum,* but only upon the middle lamella. In order to determine the relation to cellulose and calcium pectate respectively he grew these fungi for forty-eight days on culture fluids containing Swedish filter paper. He found that *Botrytis* reduced the total solids whereas these increased with the other two. He concludes that *Botrytis* is capable of dissolving cellulose, probably converting it into dextrine, whereas the others are not. He then cultivated all three upon a synthetic medium containing 1% calcium pectate. He found that these fungi grew better upon this than upon a similar medium containing arabinose instead of the pectate. On the other hand *Oidium fructigenum* did better on the arabinose medium. This result accorded with his later observations that the first three dissolve the middle lamella of host plants by enzymic secretions, whereas the *Oidium* cannot, but makes its way wholly by mechanical pressure. He is of the opinion that the enzym of *Penicillium,* which dissolves the middle lamella but not the cellulose, is different from the cellulose-dissolving enzym.

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[16] Smith, R. E., shows these names to be synonyms.

Nordhausen (1899) at about the same time made, independently, similar studies upon *Botrytis cinerea* and reached very nearly the same conclusions. He emphasizes the fact that this *Botrytis* differs somewhat in its action from Ward's lily fungus in that the enzymic solution of the middle lamella is not accompanied as a rule by the strong swelling of the inner or cellulose layers. In this respect the action is more like that of de Bary's *Sclerotinia.* He considered the swelling observed by Behrens, of the cell walls of *Symphoricarpus,* an exceptional thing for this fungus.

R. E. Smith, in a recent paper (1902) on *Botrytis cinerea,* reports that while it dissolves the middle lamella of lettuce parenchyma it causes no swelling of the residual layers. Moreover, he found the action occurred even after the fungus extract causing it had been heated to the boiling point. He considered that this action is probably identical with that of de Bary's *Peziza,* but that in Ward's lily fungus and Potter's turnip bacterium an enzym was produced different from any ordinarily produced by *Botrytis cinerea.* He emphasizes the importance of the role of oxalic acid, which is formed by this fungus and also by de Bary's.

Grüss attributed the cytolytic action of *Penicillium* to diastase. He applied the name alloölysis to such action in which the enzym evidently penetrates the substance and the solution is preceded by visible changes, forming a "corrosion zone," as

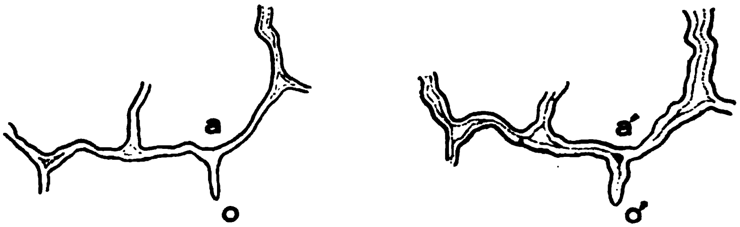

FIG. 8. Camera drawings of margin of a very thin section of carrot root tissue; a, normal; a^1, same 13 minutes after immersion in 5 per cent. solution of enzymic precipitate of *B. carotovorus*. (See also Fig. 4 where same solution was used). Since the projecting wall fragment at o^1 was most fully exposed to the cytohydrolytic action it was carefully measured to determine whether it would undergo any shortening. The enzym solution was renewed, with the addition of chloroform to inhibit bacteria, and the slide kept under observation for three weeks, but no further solution occurred.

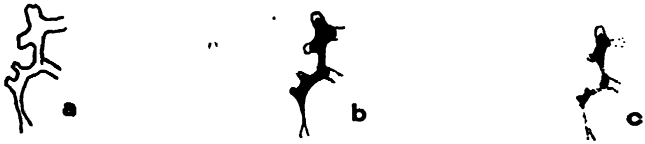

FIG. 9. Similar camera drawings of a bit of the cell wall projecting from the margin of a thin section of carrot-root tissue. The normal wall is shown in a; b, the same after 20 minutes action of 2.5 per cent. aqueous solution of Taka diastase; c, after 22 hours action, showing the gradual solution of all parts, the middle lamella being more persistent.

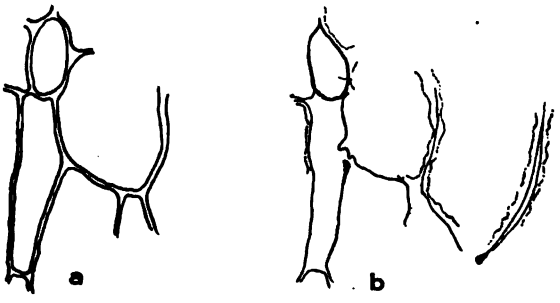

FIG. 10. Similar drawings from another preparation; normal carrot walls shown in a; b, the same after 2 hours action of 2 per cent. solution of Taka diastase. The continous lines show the more persistent middle lamellae. The inner lamellae were entirely dissolved in places.

contrasted with the surface erosion ("Abschmelzung") of starch grains by diatase.[17]

Newcombe (1899) published the results of studies upon the commercial preparation, "taka-diastase," which is the enzym-containing precipitate from the fungus *Aspergillus oryzae.* His tests upon barley endosperm sections showed a cytolytic action. The walls became hyaline, first near the middle, this change then progressing through the inner lamellae toward the cell lumina. Following this, these wholly hyaline walls (inner lamellae) began to disappear from the borders (cell lumina) toward the middle of the wall so that a faint and thin middle lamella often persisted for forty-eight hours after the beginning of the experiment. A similar melting away of the walls of the aleurone layer occurred more slowly. Newcombe also studied its action on the cell walls of the cotyledon of *Lupinus albus* with like results, the middle lamella again proving more resistant to this enzym than did the inner lamellae.

We have repeated Newcombe's work and found the results as he describes. Trial was then made of taka-diastase in comparison with the enzym from *B. carotovorus* on carrot-root walls. The results are shown in the accompanying figures 8–10.

THE CYTOLYTIC ACTION OF POLLEN-TUBES.

Elfving (1879) and Strasburger (1884) have studied the development of pollen tubes and found that in general they burrow through the plane of the middle lamella, thus passing between the cells rather than through them.

Miyoshi (1894) found the tubes capable in some cases at least of actually penetrating the walls. Both Miyoshi and Green (1894) conclude that the action of pollen tubes is such that the secretion of a cytolitic enzym must be inferred. Green made a series of careful experiments with pollen both before germination and during the process planned to demonstrate the presence of this and other enzyms which he judged to be present. He secured inulase and diastase but was unable to get evidence of cytolytic action from the extracts of any pollen he tested.

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[17] See abstract of Grüss article, *Centralbl. f. Bakt.* II. 2:585 (1896).

No later trials have come to our attention and we are therefore unable to go further than to make inferences as to the presence of a cytolytic enzym in pollen. Green concludes that it is there in spite of his failure to secure it and that it is similar to the lamella-dissolving enzym of Ward's lily *Botrytis.* The penetration of the walls observed by Miyoshi may easily have resulted from mechanical pressure without the complete absorption of the cellulose layers of the walls.

CYTOLYTIC ACTION IN SEEDS AND OTHER STORAGE TISSUES OF THE HIGHER PLANTS.

The endosperm of seeds has the cell membranes characteristically of the easily-hydrolyzed or hemicellulose type, and the same is true of other plant storage tissues such as fleshly roots and tubers. The solution of these in the normal processes of germination or growth-resumption has long interested plant physiologists.

Sachs (1862) observed the solution of the endosperm of the date palm, *Phoenix.* This was attributed to an enzym, but attempts at isolation of a soluble ferment from the seeds of another palm, *Livistonia,* by Green (1893:94) failed and it remained for Newcombe (1899:67) to secure the cytolytic enzym from germinating seeds of *Phoenix dactylifera.*

The first enzym of this class isolated from seeds was, however, obtained by Brown and Morris (1890) from barley malt. They found that the alcoholic precipitate of malt extract contained a cytolytic enzym in addition to diastase. This functions, during normal germination, leading to the solution of the endosperm walls preceding the solution of the starch granules by the diastase. The details are of interest: First, a slight swelling of the inner lamellar walls, bringing out evidence of stratification; second, the gradual solution of the modified inner lamellae, the middle lamella being the most resistant; third, the solution of the middle lamella. Newcombe (1899:52) repeated and confirmed their observations later and states that the inner lamella was dissolved down to the middle lamella within five to fifteen hours, whereas the latter persisted for from one to ten days before complete solution.

Brown and Morris (1890:500), testing the barley enzym on other tissues, found potato sections rapidly decomposed. It was found that the cell walls swelled, became differentiated into very thin laminae which later broke up into spindle-shaped fragments and ultimately disappeared with the exception of a thin layer representing the middle lamella. The artichoke, carrot and turnip behaved like the potato, but beets and apples were affected little or not at all. Heating to 60° C. rendered the enzymic solutions inactive on the walls, whereas this diastatic action withstood 70°.

Brown (1892) has since found a like enzym in oats and rye and reached the conclusion that the cytolytic action which occurs in the early stages of the digestion of these grains by animals is due to the action of the ferment present in the grains themselves rather than to the digestive juices of the animal.

Gardiner (1897:106) observed solution of the walls in the endosperm of *Tamus communis* during germination. The disorganization of the walls was accompanied by marked stratification and the middle lamella was dissolved first, the inner lamellae later.

Grüss (1896) in working upon germinating barley, observed the same changes as Brown and Morris, and applies the name "alloölysis" to the behavior. His use of the term was explained earlier in this article. He speaks of four sorts of "diastase" which may be differentiated in germinating barley, (1) translocation diastase, (2) secretion diastase, (3) glukase, (4) cytase. He holds that the last of these "must yet be held as questionable," concluding that "secretion diastase" may cause the cytolytic action and may be more and more weakened by heating above 50° C., so that it loses the power previously possessed of acting on saccharo-colloids. It is of interest to note that Grüss' use of the word "cytase" in the above connection marks the origin of this word so far as we have learned.

Reinitzer (1897) likewise refused to admit that the cytolytic action in barley is due to another enzym than diastase, although he considers that an enzym, cytase, differing from the barley enzym may occur in seeds having the walls thickened with hemicellulose as a reserve material.

Bourquelot and Herissey (1898) made trial of the enzymic action of a barley malt extract, secured by the method of alcoholic precipitation, upon a solution of pectine from gentian. They found evidence of the presence of an enzym, destroyed by heating to the boiling point, which was capable of so changing pectine that it cannot thereafter be gelatinized by the action of the clotting enzym, pectase. This is, they believe, due to the conversion of the pectine into reducing sugars. For this enzym they propose the name pectinase.

Green (1901:104) considers that they did not prove this "pectinase" to be different from the cytolytic enzym of Brown and Morris, since the French observers did not determine what constituent of the wall is affected by it. Green appears, however, to have overlooked a later publication by Bourquelot (1899:567) in which he states that when the solution of pectine was coagulated by pectase and this coagulum treated with the malt enzym solution it gradually disappeared and coincidently reducing sugar was found, showing that it was a process of hydrolysis. He considers the action of these two enzyms, pectase and pectinase, on the compounds of the pectic series analogous to that of rennet and trypsin, respectively, on casein, in that one causes coagulation of the soluble forms while the other liquefies the coagulum through hydrolysis. As confirmatory of his conclusions he cites experiments wherein he added the two enzyms simultaneously to the pectine solution. When the proportion of the pectase was larger as compared with the amount of pectinase there resulted first coagulation and then the gradual liquefaction of the coagulum. When the proportions were reversed no coagulation took place. These latter experiments would seem to disarm any suspicion that the solution of the clot as reported in the first experiment was due to bacterial development. It is, however, a matter of regret that Bourquelot gives practically no details as to his methods in these experiments, since it is evident from his statements that the changes occupied considerable lengths of time, and one would wish full assurance of the absence of bacterial growth.

In some of his other work with enzym solutions he relied upon chloroform, in some on "thymol water," both of which, we have learned, must be used with painstaking, if bacterial growths are to be suppressed with certainty. In some cases he has depended upon frequently raising the temperature of the solutions to 50° C. to destroy bacteria.

In spite of these criticisms, however, it seems to us that the conclusions of Bourquelot and Herissey must be accepted, viz., that there is present in barley malt an enzym, their pectinase, which hydrolyzes pectine, and also an enzym, presumably the same, which hydrolyzes the pectic coagulum. Since this latter is regarded by most chemists, including Green, as calcium pectate and the same as the middle lamella in composition, the name pectinase becomes applicable to the middle lamella-dissolving enzym of barley malt.

The strongest objection to this dictum is that there may be insufficient ground for their conclusion that the action upon the pectine and the coagulum is due to one and the same enzym. These are closely related compounds and it seems to us their conclusion must be accepted until the contrary is proved. There is nothing in their publication to indicate whether or not they regarded their "pectinase" as capable of causing the solution of the hemicelluloses also. Since, however, they do not state to the contrary and later name only three enzyms as occurring in barley malt[18] (diastase, trehelase and pectinase), we are led to infer that they so regarded it, and therefore, as Green says, they did not clearly define their "pectinase" as different from Brown and Morris' cytolytic enzym, for which Grüss later proposed the name "cytase."

Newcombe (1899) made a comparative study of cytolytic enzyms in the course of which he repeated and verified the observations of Brown and Morris upon the barley enzym and secured similar soluble ferments from some other germinating seeds. He found the enzymic extract from the cotyledons of *Lupinus albus* to be strongly cytolytic and but feebly amylolytic. Extracts from both the cotyledons and the endosperm of *Phoenix dactylifera* showed cytolytic and amylolytic activity, and here again the cytolytic action was relatively greater. There was, however, a noteworthy difference between the two date-seed extracts in that the one from the cotyledons had much greater amylolytic strength and relatively weaker cytolytic activity. This showed that the action on starch and the action on cell wall were distinct and independent processes. This evidence was further strengthened by comparisons of these with barley malt extract and with taka-diastase, both of which were found relatively stronger in amylolytic action. This seems conclusive as against Reinitzer's contention that the cytolytic action was due to diastase.

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[18] Bourquelot, Em. Sur l'hydrolyse des polysaccharides par les ferments soluble. *Jour. Pharm. et Chem.* 16:581. 1902.

Further comparisons showed also a lack of correlation between the rate of solution of the middle lamella and inner lamellae, respectively. Thus the five solutions were made to such a strength that all showed a like rate of action on starch. Sections of barley endosperm were then immersed in them and the periods necessary for complete solutions of inner and of middle lamellae, respectively, in each found to be as follows:

Source of extract.	Solution of inner lamella.	Solution of middle lamella.
Lupinus cotyledon	required 9 hours	required 21 hours.
Date endosperm	" 9 "	" 118 "
Date cotyledon	" 21 "	" 118 "
Taka diastase	" 94–116 "	" over 312 "
Barley malt	" 94–116 "	" " 312 "

These figures also serve to indicate the differences in the relative amylolytic and cytolytic activities discussed above.

Green in the second edition of his work on Fermentation (1901:105) cited these observations of Newcombe's as confirming his earlier idea that "there appear to be two varieties of cytase, one attacking most readily the middle lamella, the other the layers deposited upon it."

It only remains to refer in this connection to the accounts of two other enzyms of the cytolytic class.

Effront (1897) obtained from the carob bean a ferment he calls caroubinase. This acts upon a peculiar carbohydrate caroubin, differing from both starch and cellulose, which he obtained not only from this bean but also from barley and rye. Caroubinase has been classed with the cytases, but differs from those previously discussed in that it withstands a temperature as high as 80° C. It is of interest in the present discussion only as suggesting that other classes of cytolytic enzym may be revealed upon further investigation.

Wiesner (1885) states that there occurs in gum arabic an enzym capable of transforming cellulose into gum and mucilage. This apparently needs further study before acceptance, but it again suggests the same idea.

CLASSIFICATION AND NOMENCLATURE OF THE CYTOLYTIC ENZYMS.

In the first place we would again call attention to the fact that these studies have added strength to the argument that the cytolytic enzym or cytases stand in a class apart from the amylolytic enzyms or diastases. This is evidenced by the uniformly lower point of thermal destruction of the cytases; by the fact that cytases occur which show no diastatic action whatever, e. g., that of *B. carotovorus;* by the further fact that diastases occur which show no cytolytic action whatever, e. g., that of saliva.[19] Where enzymic solutions show both cytolytic and amylolytic activity they have been found to exercise these in unlike ratios, sometimes one and sometimes the other predominating, as shown by Newcombe. The only conclusion permissible is that in such cases two enzyms occur in mixture in varying proportions.

As to the cytolytic enzyms, we are convinced that Green is right in his conclusion that these fall into two natural groups, the one active upon the pectic, and the other upon the cellulose elements of the cell membrane. Since both of these elements include a complex of chemical compounds we would naturally expect a corresponding variety to be shown in the enzyms which act upon them. There is, indeed, evidence that this does occur. The fuller understanding of the chemistry of the cell membranes must, however, precede such further subdivision of the enzyms acting upon each. For the present we can at least accept the following as representing well-defined groups of components in the simpler or less modified plant tissues: 1. True celluloses. 2. Hemicelluloses. 3. Pectic compounds. In the more modified tissues there are other compound celluloses, ligno-cellulose, etc., which do not here concern us.

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[19] Cf. Brown, H. T., 1892:356.

Evidence is not lacking that there are enzyms capable of hydrolyzing the true celluloses, but further study is necessary before their relationships can be defined. The cytolytic enzyms, which have been studied in sufficient detail so that we can characterize them, act only upon the last two of these three classes. As already indicated, we consider these enzyms to be as clearly separable into two groups or kinds as are the wall elements upon which they act, and we believe it must conduce to clearness of understanding if a distinct name be accepted and defined for each of these kinds of enzym.

The enzym of *B. carotovorus* and the related soft-rot bacteria is a good example of one acting upon the pectic compounds, but not hydrolyzing the hemicelluloses. Such an enzym has heretofore been referred to usually as "cytase." If the cytolytic enzyms are to be differentiated some more specific name must be found. Following the custom in naming enzyms, pectase would be the right name had it not been applied to Fremy's clotting enzym. If one accepts the grouping of the celluloses outlined by Cross and Bevan and considers these pectic elements of the wall to occur in compound with cellulose or pecto-celluloses preference might be given to the name *pecto-cellulase.* This is not free from objection, however, since their term pectocellulose was applied to a hypothetical compound made up of non-hydrolyzable cellulose elements and pectic elements which pass into solution under the influence of this enzym. This name if adopted would suggest an enzym capable of action on both these components alike.

All things considered, we favor the name *pectinase,* which was suggested by Bourquelot and Herissey, as already explained. An objection to this name is that it was originally applied to the enzym which hydrolyzes pectose. Later it was found that this same extract hydrolyzes the coagulum, or pectic clot. It was inferred that this latter action is due to the same enzym as the former. Although this was not demonstrated, it seems to us sufficiently probable to justify its acceptance as a satisfactory working hypothesis, and if so this name must be accepted for the enzym under discussion. As more broadly defined, then, *pectinase* is capable of hydrolyzing pectose when in solution so that it will no longer yield a clot under the influence of pectase, and also of hydrolyzing the pectic coagulum and the pectic elements in the cell wall, viz., the middle lamella and parts of the inner lamellae of certain tissues. As a further justification of the acceptance of the name pectinase in the broader sense we note a tendency in this direction in certain writings which have appeared since its promulgation.[20]

Bourquelot and Herissey did not so define their enzym as to exclude its action on hemicellulose; in fact, the barley malt solution with which their work was done does so act. As already explained, this hydrolytic action on hemicellulose predominates in the cytolytic action of taka-diastase, although action on the pectic compound occurs also. Since we have made some observations upon this taka preparation we will base our discussion on that. Two explanations are available for action such as occurs here, and in like cases where there is solution of both of these wall elements. The first is that only one kind of cytolytic enzym is present, which is allied to pectinase but differs from it in that it acts primarily on hemicellulose and to a less degree on the pectic elements. The second is that two distinct cytolytic enzyms are present in mixture, viz., a small amount of pectinase, which causes the hydrolysis of the pectic elements, and a relatively larger amount of another enzym which acts on the hemicelluloses. Newcombe's results, referred to earlier in this paper, strongly favor the second of these two possible explanations and exclude the first.

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[20] See use by Lepoutre (1902), also Oppenheimer (1901:193).

Accepting the conclusion that there is an enzym other than pectinase in taka-diastase, barley, malt, etc., of which the hydrolytic action is chiefly or wholly on the hemicellulose elements of the cell membrane, we need a distinctive name for that also. The one introduced by Oppenheimer (1901:187), cellulase, seems fit except that it is too general. It implies an activity on the celluloses generally, and especially on the celluloses proper. This enzym, which acts only on the hemicellulose, may better be termed *hemicellulase.* This is a self-explanatory name and leaves the name cellulase to be applied either in a more general sense to all cellulose enzyms, including this hemicellulase, or, as would be preferable in our opinion, reserving it for application to the enzyms which hydrolyze the celluloses proper, as recently studied by Omelianski (1902). These terms, pectinase and cellulase, have heretofore been used rather vaguely as synonyms of Grüss' term cytase, i. e., as applicable to cytohydrolysts generally. If they be restricted to the more exact usage defined above, it leaves the words cytohydrolyst, or better cytolyst, and cytase as convenient and satisfactory terms for use in the broader sense to include in a general or indefinite way both of the above, and indeed any other related enzyms capable of hydrolyzing the cell membranes.

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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 148

JANUARY, 1910

A Bacterial Soft Rot of Muskmelon, Caused by Bacillus melonis n. sp.

BURLINGTON:
FREE PRESS ASSOCIATION,
1910.

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ERRATA.

A combination of circumstances has conspired to make this issue full of errors, for none of which is the author, who had removed to another section of the country, in any way responsible. No attempt is made to correct typographical errors.

Page.

367. IV. 3. *Add* the words "Plate cultures with round colonies and saucer-shaped liquification."

368. 9. *For* starch jelly *read* silicate jelly.
Insert. "9 Starch jelly. Good growth in this medium containing Fermi's solution or beef broth."
Renumber 9-13, *reading* 10-14.

370. 16. *Insert* after words "There was good growth in broth containing" the words ".005% of formalin, fair growth in broth containing."

77. line 19. *For* tubers *read* tubes.

79. line 24. *For* recurred *read* occurred.

84. line 5. *For* in *read* a.

1. table line 4. *For* 47.4 *read* 47.9; *for* 48.9 *read* 47.9.

4. line 6. *Insert* at end the words "and from cultures 15 days old 22 c.c. of N/1 hydrochloric acid."

[illegible]. table line 2. *For* 13.2 *read* 15.2.

6. table line 7. *For* 32.3 *read* 22.3.

98. table (Glycerin) line 13. *For* 18 days *read* 15 days.

399. table line 9. *For* 15.3 *read* 15.5.
table line 13. *For* 30 *read* 20.

402. line 15. *For* .01 *read* 0.1.

403. line 18. *Insert* after (K^2HPO^4) the words "and .05 grams of monopotassium acid phosphate (KH^2PO^4) were and," eliding the verb "was."

404. *Omit sentence* beginning "These tubes."
Table line 5. *For* 3.80 *read* 3.90.

406. line 2. *For* 20-20° *read* 20-25° C.

408. line 1. *For* .05 *read* 0.5.
bottom line. *Insert* after word "of" the words "+ 5, + 10, and + 15, and fair growth in that having a reaction of."

410. line 21. *For* 48 hours *read* 24 hours.

413. line 22. *Insert* after figures 1.-1.7 the word "microns."

There are divers typographical errors in the bibliography, mostly misspelling. Such as are likely to mislead are as follows:

415. Harrison. *For* solanisaprum *read* solanisaprus.
" *For* 186 *read* 166.
Jones. *For* 229 *read* 299.
" *For* cytolic *read* cytolytic.

Figure 9 line 2. *For* ½ obj. *read* 1/12 obj.

BULLETIN 148: A BACTERIAL SOFT ROT OF MUSKMELON CAUSED BY BACILLUS MELONIS n. sp.

By N. J. Giddings[1]

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[1] Formerly assistant botanist of this station; now bacteriologist of West Virginia station.

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Since this bulletin is of a technical nature and will be used primarily by bacteriologists for reference, the following brief summary is inserted before the body of the article.

SUMMARY

I. *Occurrence and character of the disease:*

A soft rot of the muskmelon caused by a bacillus. The character of the decay is similar to that of other vegetable soft rots, but the organism differs from the soft rot type, *Bacillus carotovorus* (Jones).

II. *Pathogenesis:*

1. Pathological histology.—The tissues very rapidly disorganized and cells dissociated, due to the enzymic softening of the middle lamella. Material imbedded, sectioned and stained, showed bacteria working along the plane of middle lamella.

2. Inoculation experiments.—Wound inoculations in muskmelon generally gave complete decay in from three to seven days. Wound inoculations in citron and cucumber fruits resulted in decay. Raw sterile blocks of muskmelon and citron fruits, carrot, turnip and beet roots and potato tuber were decayed. Portions of the tissue of carrot, turnip, and potato were considerably discolored. No decay was secured in inoculated wounds in fruits of squash or summer squash. Inoculations of muskmelon upon unbroken surface did not bring about decay.

III. *Morphological characters:*

1. Form.—A bacillus; short rods with rounded ends occurring most often singly, but frequently in chains of two or three.

2. Size.—Stained specimens of young cultures averaging about .7 micron by 1.2 microns; unstained specimens about .9 micron by 1.6 microns.

3. Agar hanging block.—Organisms generally occur as single rods, sometimes in chains of two or three, very rarely in chains of four to five. The orientation of chains was irregular.

4. Endospores.—None were found.

5. Motility.—Very actively motile in decaying tissues and young liquid cultures. Four to six peritrichic flagella readily stained by Loewit's method.

6. Capsules.—None observed.

7. Involution forms.—None of importance noted.

8. Staining reactions.—Young organisms readily stained with aqueous solutions of fuchsin, gentian violet or carbol fuchsin. Not stained by Gram's method.

IV. *Cultural characters:*

1. Nutrient broth.—Strong transient clouding and slight sediment. No pellicle or ring formation.

2. Agar.—Filiform growth entire depth of stab. Slightly spreading with umbilicate elevation, slightly contoured. Surface colonies round to amoeboid. Buried colonies spindle shape. No fermentation in carbohydrate agars. Acid production in lactose-litmus agar.

3. Gelatin.—Liquefaction apparent in 24 hours, at 20° C., complete in 14 days. Stab cultures with infundibuliform liquefaction.

4. Cooked potato.—Growth abundant, spreading, slightly contoured, glistening, and with a decided odor of decaying potatoes.

5. Raw vegetables.—Good growth on sterile blocks of muskmelon, citron, carrot, turnip, beet and potato. Discoloration of potato, beet, turnip and carrot.

6. Milk.—Coagulated in 24 to 48 hours at 30° C. No digestion. Cultures in milk were alive at the end of 36 days. Litmus milk coagulated and reddened in 3 days. Litmus completely reduced in 30 days. Return of color in 40 to 60 days.

7. Fermentation broths.—Good growth in saccharose, lactose, maltose, dextose, mannite, glycerin, and asparagin; slight growth in urea; good growth in closed arm in mannite, saccharose and asparagin; no growth in closed arm in glycerin.

8. Blood serum.—Growth effuse, glistening and slimy with echinulate edges. Substratum became clear in 10 to 15 days. Slow but distinct liquefaction.

9. Starch jelly.—Very abundant growth. Inclined to be spreading with echinulate edges, slightly contoured, umbilicate elevation, and slimy. Slight greenish yellow discoloration of substratum.

10. Fermi's solution.—Strong, persistent clouding with ring formation, and considerable sediment.

11. Uschinsky's solution.—Very strong growth in this medium, with ring and pellicle formation and large amount of sediment. Disagreeable odor of hydrogen sulphid.

12. Cohn's solution.—No growth.

13. Special media.—Good growth in whey medium, curd medium, curd medium with lactose, and casein medium with mannite; slight growth in casein medium. Coagulation in casein with mannite.

V. *Physical and biochemical characters:*

Maximum temperature of growth 40° C.; [1]minimum temperature, 0° to 1° C.

1. Temperature relations.—Optimum temperature for growth about 30° C.; slight growth at 37.5° C; thermal death point 49 to 50° C.

2. Growth in carbon dioxide.—There was very slight growth in gelatin stab and agar stab cultures.

3. Indol production.—A slight reaction was secured in 10 days; more pronounced reaction in 20 days.

4. Nitrite production.—Abundant in 5 days.

5. Ammonia production.—Abundant from fermentation tube cultures of asparagin broth; none in broth, gelatin, milk or urea.

6. Acid production.—Slight in mannite, urea, glycerine, dextrose, lactose, saccharose, and maltose; pronounced in milk.

7. Gas production.—No gas in fermentation tubes of lactose, maltose, dextose, saccharose, glycerin, or mannite; slight gas production in fermentation tubes of asparagin broth; abundant in fermentation tubes of milk, this gas being at least 99% carbon dioxid. A whey medium, secured by coagulating milk with rennet, gave 30 to 54% gas, of which 99% was carbon dioxid. No gas was produced in some special casein media which were tried as substitutes for milk. Analyses of fermented milk showed a remarkable diminution in lactose content with a slight increase in acid content, which was not, however, sufficient to account for the loss in lactose. It is thought, therefore, that some lactose was used up in the production of carbon dioxid. Distillation of inoculated milk at the end of 15 days gave some evidence of alcohol.

8. Hydrogen sulphid production.—This was found in cultures on nutrient broth and cooked potato.

9. Odor.—No very distinctive odor was noted.

10. Growth over chloroform.—A good growth in 24 to 48 hours in tubes containing 5% of chloroform.

11. Toleration of sodium chlorid.—Good growth in nutrient broth containing 1, 2, 3, 4, 5, and 6% additions; a fair growth in those containing 7%; and slight growth in those containing 8%. Organisms were killed in 10 days in tubes containing 9 or 10%.

12. Toleration of hydrochloric acid: There was good growth in broth having reactions of +5, +10, +15, and +20; a slight growth in broth having reaction of +25; and no growth in media having a higher reaction.

13. [1]Toleration of oxalic acid.—The organism grew in a beef bouillon acidified to +45 and +47 with oxalic acid, but did not grow in one acidified to +52.

14. [1]Toleration of malic acid.—Growth was secured in beef bouillon acidified to +37 with malic acid.

15. Toleration of sodium hydroxid.—Good growth was secured in broths incubated in carbon dioxid free atmosphere

and having reactions of —5 and —7.4. Growth was not secured in such tubes having reaction of —10.2.

16. Effect of germicides.—Good growth was secured in broth containing .02% of phenol crystals; fair growth in broths containing .05% and .08%; very slight growth in broths containing .09% and .11%; no growth in the presence of .18% or more of phenol. There was good growth in broth containing .01% very slight growth in broths containing .02% to .04%; none in the presence of .05% or more.

17. Desiccation.—Organisms were killed by drying for 7 days, and vitality was greatly reduced after drying for 68 hours.

18. Insolation.—Exposures of 15 minutes killed 80% of the colonies, while an exposure of an hour killed all the colonies.

VI. *Remedial measures:*[1]

Spraying with bordeaux mixture or other fungicides recommended as a preventive measure, coupled with lifting and turning of the melons, and irrigation if needed. Diseased melons should be immediately destroyed. Rotation of crops should be practised in a field where the disease has occurred.

OCCURRENCE AND CHARACTERS OF THE DISEASE

During September, 1907, Mr. E. S. Brigham, of St. Albans, suffered a considerable loss in a field of Montreal muskmelons which he was growing for fancy market. This crop was in a measure an experimental one, being grown in cooperation with the horticultural department of the Station, to determine whether such a crop would prove profitable in this state.[1] The plants were grown in frames, sash being kept over them until the latter part of August. The season was very dry until September, and as a result the growth of the melons had been somewhat slow. During early September, however, there were heavy rains, and these, combined with warm cloudy weather, induced a very sudden increase in growth, which resulted in numerous cracks in the skin and flesh. These cracks furnished excellent points of entry for pathogenic organisms, and the succulent tissue evidently furnished a favorable medium for their growth. As a result the melons were attacked in early September by a soft rot, which destroyed about twenty-five per cent of the crop before the end of the season. The decay generally began on the under side of the fruit and spread rapidly. The skin became somewhat shrunken over the diseased area but generally remained unbroken. When the melon had entirely collapsed there was usually some frothing and a very disagreeable odor. Some of the melons which became diseased lay in natural contact with the ground, but others were fruits which had been placed on blocks.

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[1] Dr. E. F. Smith of the Bureau of Plant Industry of the U. S. Department of Agriculture, kindly contributed confirmatory and additional observations at several points. He determined the liquefaction of Loeffler's blood serum, the maximum and minimum temperatures in peptonized beef bouillon, and the toleration of the organism for oxalic and malic acids; and he advised the writer as to certain points concerning the growth of the organism on Fermi's solution.

Specimens of the diseased melons were first brought to the writer on September 14, by the station horticulturist. Microscopic examination was made at once. It was found that the decaying tissues swarmed with motile bacteria, and that the cells were dissociated. A large number of agar plates were poured from one of these melons which was in the early stages of decay. Numerous bacterial colonies appeared on these plates within less than 30 hours. The colonies were practically all similar in appearance and broth transfers and inoculations were made from some of them at this time. Transfers were made first so as to secure the organism in pure culture, and then inoculation was made from the same colony. In 48 hours the decay was well under way in melons thus inoculated. It seemed evident that the decay was caused by one organism and all further cultures were taken from these similar colonies. Some further inoculation experiments were made and the organism was retained in pure culture, in order that a detailed study of its characters might be made.

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[1] See for detailed account of the experiment and conclusions, Stuart, Wm., The Market Muskmelon Industry, Vt. Sta. Rpt. 20, pp. 358-366 (1907). Considerable of the field data here given is taken from this article.

PATHOGENESIS

PATHOLOGICAL HISTOLOGY

A microscopic examination of the diseased tissues from inoculated muskmelons gave evidence that the organism had invaded the intercellular spaces, dissolving the middle lamella so that the cells were frequently seen floating around loose. In many cases also the bacteria were seen to have fully invaded the spaces between the cells. The remaining part of the cell walls appeared swollen, but bacteria were not observed in the interior of cells which had recently been separated from the others through the disorganization of the middle lamella. For more critical examination, sterile blocks of raw muskmelon were cut and dropped into young broth cultures of the organism, in which they were allowed to remain for 15 to 20 hours. These pieces were then cut into smaller blocks and killed and fixed in boiling absolute alcohol. They were imbedded in paraffin, sections cut, and various staining reagents tried, in order to bring out the histological relations of the organisms and tissue. This method confirmed the conclusions stated above, that the invasion is strictly intercellular and that the principal effect on the wall is the solution of the middle lamella. Good staining reactions were secured with Zeihl's carbo-fuchsin, bismarck brown, and Loeffler's alkaline methyl blue. A differential stain was secured by using bismarck brown for two minutes and the methyl blue about twenty seconds. The action of the organisms upon the middle lamella appears similar to that of the carrot rot organism, *Bacillus carotovorus,* Jones.

INOCULATION EXPERIMENTS

All the vegetables used for this purpose were carefully cleaned and washed previous to inoculation, but were neither soaked in nor washed with corrosive sublimate. Such as were inoculated in the laboratory were wrapped with moist absorbent paper and placed in moist chambers at 20° to 27° C.

Melon: Melon No. 1. This specimen, about three fourths grown, was secured from a local market gardener. It was inoculated on Sept. 18 from an agar culture 24 to 48 hours old, using a 2 mm. loop to transfer some of the condensation water to a small skin wound made with a sterile scalpel. In 24 hours a watery spot about one-half inch in diameter appeared around the point of inoculation. In 48 hours this spot was about one inch in diameter, and a little water oozed from the wound. On opening the melon tissue was found to be somewhat softened in an irregular funnel shaped section extending from the surface into the cavity, its diameter at the point where it entered the cavity being about one sixth of an inch.

Melon No. 2. A full grown, unripe, nutmeg was secured from a local gardener. A small wound was made in the surface with a sterile, platinum-iridium needle. The inoculation was made from a 48 hour old agar culture, in the same manner as with No. 1. In 24 hours a softened area of one-half inch in diameter had developed around the point of inoculation, which in 48 hours was two and one-half inches in diameter, the skin over the softened portion having sunken until nearly flat. At the end of 72 hours one half of the melon had fallen in and the next day it was entirely softened.

Melon No. 3. A nutmeg, handled in the same manner as No. 2. At the end of 24 hours the softened area was about one-half inch in diameter, in 48 hours it was three inches, and at the end of the third day the melon had fallen in and, save a portion of firm flesh on one side, was entirely softened.

Melon No. 4. A cantaloupe, handled in the same manner as No. 2. In 24 hours the softened area was about one-half inch, and in 48 hours about three inches in diameter. In 72 hours it had entirely decayed and showed slight frothing.

Melon No. 5. A nearly full grown nutmeg, inoculated on the vine. Inoculation was made as with melon No. 2 and several thicknesses of moist filter paper were wrapped around it. In 48 hours a softened area about one-fourth inch in diameter had developed, which at the end of three days was about one-half inch, and in five days about three-fourths of an inch in diameter. In ten days the melon had fallen in. The weather was quite cool when the field inoculations were made, which may account for the slow progress of the decay.

About twenty melons were inoculated during the fall of 1907, and about a dozen during the next fall; four of these while on the vines and the remainder in the laboratory. Decay followed every wound inoculation with results essentially like those described above. A number of these melons were opened at different stages of decay in order to note the mode of progress. The organisms appeared to work in from the surface, spreading toward the center and widening out under the skin at nearly the same rate, so that a funnel shaped area was first softened, which finally penetrated into the cavity. As soon as the organisms entered the cavity they spread very rapidly over the entire interior surface and worked from this toward the skin. Whenever more than one melon was inoculated, and in some cases when only one was under trial, controls were made by wounding another part of the same melon, or other melons, as though to make inoculations. These were in all cases treated in the same way as were the inoculated wounds, save that no organisms were placed in them. Rot developed in none of these control wounds. Furthermore, two healthy, uninjured melons while growing on the vines were sprayed with portions of broth culture of the organism, 24 to 48 hours old, but no signs of decay occurred within seven days.

Cucumber. Nine cucumbers, varying in age from those quite young to such as were full grown but not ripe, were inoculated in the same manner as were the muskmelons. These showed no signs of decay, other than a very small spot, until four days after inoculation. The invasion by the organism then became evident in the younger cucumbers, and in seven days after inoculation four of the fruit were entirely collapsed. Three of the others showed no signs of decay, while the two remaining, which were opened at this time, revealed a small decaying area around the point of inoculation. The organism is evidently capable of decaying cucumbers, but with much more difficulty than in the case of muskmelons.

Citron. Specimens of citron fruit were secured in the market, cut with sterile knives, and inoculated on the freshly cut surfaces, taking material from a 24 to 48 hour old broth culture, using a 2mm. oese. The organisms spread very rapidly in this tissue, the citrons being decayed on the fourth or fifth day.

Other vegetables. Several fruits of squash and summer squash were inoculated, but no decay ensued. Sterile blocks cut from the roots of raw carrot, turnip and beet, and from raw potato tubers were quite rapidly rotted, as will be described under cultural characters.

These results indicate that the organism in question is different from *Bacillus carotovorus,* Jones, since that organism was found in no case to cause decay of the beet. Moreover its invasion of the potato tuber was less active than that of this melon-rot organism.

MORPHOLOGICAL CHARACTERS

The morphological characters of the organism were studied in broth and agar cultures 24 to 48 hours old, with the exception of the work done in searching for spores.

Form. This organism is a bacillus having rounded ends and occurring generally as single cells, frequently in pairs, and occasionally in chains of three or, rarely, of four or five. The grouping in both agar and broth cultures was very similar.

Size. Stained specimens from cultures about 36 hours old, incubated at 25° C., using gentian violet as a stain and taking measurements with an ocular micrometer, afforded dimensions of .5 to .8 by .9 to 1.5 microns. To secure measurements of greater exactness, photomicrographs of the living organism on agar hanging block cultures, and of the divisions on a stage micrometer, were taken under identical conditions. The results indicated that the living organism in agar hanging block cultures possessed a diameter of .8 to 1. micron and a length of 1.5 to 2. microns. (See figure 9).

Cultures on agar hanging blocks. The agar hanging block cultures were made by taking a transfer from a young broth culture and smearing it over the surface of a small block of sterile agar. A cover slip was then placed upon the block with the inoculated side next to the glass. These were allowed to remain at room temperature, 22 to 25° C, and the development of the organisms was observed. There appeared to be no special grouping of the organisms other than has already been noted above under "Form."

Staining reactions. The organism was well stained by a watery solution of gentian violet, watery solution of fuchsin, and carbol-fuchsin. The latter, applied cold, gave a deep color in 30 seconds; the others required about one and one-half minutes. The organisms from young cultures appeared to be strongly plasmolyzed by carbol-fuchsin, giving what might be called a polar stain, the ends of the rods being generally stained as though the protoplasm had left the middle portions and gathered at the ends. The organisms did not stain by Gram's method.

Flagella. The organisms were actively motile in beef broth, Fermi's solution, Uschinsky's solution, and other liquid media incubated at 20°, 25°, or 30° C. They were also very actively motile in freshly invaded muskmelon tissues. The movements were frequently darting. They were found to be motile by means of 4 to 6 peritrichic flagella. Cultures in a medium composed of one drop of Uschinsky's solution to seven c.c. of distilled water and incubated for 18 hours at 25° C. gave the best material for staining. Material transferred directly from this to clean cover slips and stained by Loewit's method showed excellent flagella. Good material for staining was also secured by using the condensation water from agar stroke cultures 24 to 36 hours old, making a dilution thereof in sterile distilled water. Fair results were secured by staining according to Pitfield's method, and less satisfactory results, showing a few flagella poorly stained, by VanErmengem's method.

Spores. In no case has anything resembling spores been seen, nor has there been any indirect evidence of spore formation. Transfers were made to broth from nutrient agar cultures and from potato cultures 30 to 60 days old. These inoculated tubers were then placed at once in a water bath at 65° C., and were in all cases killed by a 10 minute exposure.

Capsules. Capsule formation was noted in no case.

Involution forms. No involution forms worthy of note were observed.

CULTURAL CHARACTERS

The culture media used were carefully prepared following directions as given by Smith[1] and the publications of the American Public Health Association.[2]

Once distilled water was used in preparing all media, unless otherwise stated. The formula used for making nutrient broth was Witte's peptone, 10 grams, Liebig's extract of beef, 5 grams,

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[1] Smith, E. F., Bacteria in Relation to Plant Diseases, Vol. I, (1905).

[2] Report of Committee on standard methods of Water Analysis, American Public Health Association.

C. P. sodium chlorid, 5 grams, distilled water, 1 litre. The reaction of all media containing nutrient broth was plus 10, Fuller's scale, unless otherwise noted, the titration being made with N/20 sodium hydroxid, using phenolphthalein as an indicator. For all cultures, unless otherwise specified, culture tubes about 13. by 1.5 cm. in size were used containing 7 c. c. of the medium. All transfers, except those for determining spore production, were made from one to four day old broth cultures. Transfers to fluid media were made with a 2 mm. loop, and those to solid media were made with a straight needle.

NUTRIENT BROTH

The growth in nutrient broth was rapid with strong clouding. No pellicle or ring formation was noted. At 30° C. it was very strong in 24 hours and did not increase perceptibly after 48 hours. The medium became clear in about two months. A slight amount of sediment formed which showed but slight increase at the end of a month.

AGAR

All agar media contained 1.5% of agar flour.

Agar stab cultures showed a medium filiform growth along their entire depth. There was a slight but not well marked tendency in some tubes toward a villous or papillate growth along the line of puncture. The surface growth was abundant and spreading, frequently extending to the tube walls if the medium had been melted just before inoculation and was in consequence moist. There was no sign of liquefaction or gas formation in any agar tube.

Agar stroke showed good growth within 24 hours, which was slightly spreading and filiform with wavy margins. The elevation was umbilicate, the surface slightly contoured, and the growth transluscent with a slight opalescence. It was glistening and slimy, without color, and did not discolor the medium. (See figure 12).

Carbohydrate agars. These were made up containing respectively 5% saccharose, dextrose, lactose, mannite and glycerin. Other series contained 2% of all these except glycerin. Shaken cultures were made in each of the above agars and in ordinary nutrient agar. A control culture of *Bacillus coli* was also made on each of these agars. The melon rot organism showed good growth at or near the surface in all tubes in 24 hours, the best growth being secured upon 5% glycerin and the least upon 5% saccharose, 5% dextrose, and upon plain nutrient agar. The buried colonies were apparent in 2 days and at the end of the week the medium was strongly clouded by their great numbers, which were much more numerous toward the surface then deeper. The tubes of *B. coli* showed well marked gas production in each medium save the plain agar, but no sign of gas production appeared in any tube inoculated with the melon rot organism.

Lactose-litmus agar. Agar containing 2% lactose was used in this series of cultures. Series (A) was prepared by adding to this 2% of a solution of one part of C. P. litmus in fifteen part of water, and series (B) by adding 5% of neutral litmus solution.[1] Both shaken and stroke cultures were made upon each of these media. Within 24 hours a slight acidity developed in the shaken tubes of A, and in 48 hours marked acid production had recurred in both shaken and stroke cultures of both A and B. These remained unchanged except for a slight deepening of the red color until the end of a week, when slight bleaching in the stroke cultures of B was observed. In ten days the shaken cultures of B were entirely bleached except a very little near the surface, and the shaken cultures of A showed slight bleaching. At the end of 15 days the A tubes were about one-half bleached, and B tubes entirely bleached. No gas formed in any tube. The C. P. litmus gave the better results with both these organisms. It indicated acid production by a bright cherry red, whereas the other medium only showed a dull red tint.

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[1] See Prescott and Winslow, "Elements of Water Bacteriology," p. 126. (1904.)

Agar plate cultures. The growth was very rapid at from 25 to 30° C., forming colonies over 1 mm. in diameter in 18 hours at 25° C. In general the colonies were round but occasionally became amoeboid, the surface was smooth with very slight convex elevation, the edge entire and the internal structure finely granular. The colonies were slightly opalescent with moist, glistening surface. Buried colonies were gradually spindle shaped but occasionally elliptical.

GELATIN

Gelatin stab cultures showed a slight liquefaction after 24 hours at 20° C. The growth along the line of puncture was filiform in 18 to 24 hours, but liquefaction began almost at once so that it was hard to secure any other growth characters. At the end of a week the gelatin was about 80 per cent or more liquefied, and there was a large amount of flocculent sediment. Complete liquefaction resulted in 14 days. Gelatin tubes inoculated and placed at 25° C. were about one-third liquefied in 24 hours, and in 48 hours were entirely liquefied. The liquefaction in all stages and at both temperatures was infundibuliform to saccate. (See figure 12).

Gelatin plate cultures at 20° C. showed liquefaction within 40 hours. The colonies at first were round, becoming in about 36 hours reticulate; then after 4 to 8 hours liquefaction began and the colonies again became round, the edges after this stage being floccose. The colonies remained round and the liquefaction was saucer-shaped.

COOKED POTATO

The growth was light yellow, spreading, abundant, slightly contoured and glistening. There was good growth in 48 hours. The growth was slimy and the tubes had a decided odor of decaying potatoes. There was no discoloration. In 15 days the growth in cultures at 25° and 30° C. was much less conspicuous than at first. At 37° C. there was no visible growth.

RAW VEGETABLES

Sterile blocks of muskmelon, citron, potato, carrot, beet and turnip were secured in the following manner: The room which was to be used for cutting the blocks was carefully sprayed with water, wetting down the walls and sending a fine spray throughout the air of the room. The vegetable used was first carefully washed and then either soaked or washed for 3 to 7 minutes in a 1-1000 solution of mercuric chlorid. The outer portions were then removed with hot sterile knives, sterile blocks cut from the interior in the same manner, and these blocks were placed in test tubes containing 1-2 c.c. of sterile distilled water. Before inoculation the tubes so prepared were in all cases incubated for 2 days at 25° C. and any tube which did not appear sterile at the end of that time was discarded. Out of nearly 300 blocks cut in this manner there were only some half dozen which did not appear to be sterile after such trial incubation.

Muskmelon. Blocks of raw muskmelon were entirely collapsed in two days. The blocks had a watery appearance at the end of 20 to 24 hours, and soon sank down into the water forming a semi-fluid mass. There were some indications of gas production.

Citron. Inoculated blocks of this vegetable showed much the same appearance as did the blocks of muskmelon, but frequently did not collapse until the third day after inoculation. There was no discoloration other than the watery appearance observed in the muskmelon. Slight gas production occurred.

Carrot. Inoculated carrot blocks were entirely softened in three to five days. These did not collapse spontaneously as did the muskmelon and citron, but upon shaking would do so. The portion of the block above the water was darkened, frequently becoming almost black. Slight gas production occurred.

Turnip. Blocks of this vegetable were discolored to the extent in some cases of turning nearly black and frequently in cases they showed a somewhat mottled appearance. The blocks were usually considerably softened in three to five days, but less so than the carrot blocks; and they did not collapse as readily. In some cases, where there was insufficient water in the tube to keep the surface of the blocks moist, growth was retarded or fully checked and little or no decay resulted.

Beet. The immersed portions were completely softened within three to five days and entirely so within a week. They did not collapse however, even upon shaking, but a platinum needle could readily be passed through them anywhere. The non-submerged portions were nearly black. Slight gas production occurred. In case of insufficient moisture the growth was retarded or even completely checked in the same manner as occurred when the turnip was used.

Potato. Blocks of potato were nearly one-half softened within three days. If pressed with a platinum-iridium needle the submerged portion would entirely collapse and spread around as a thick mass. These blocks were entirely softened within a week, in case there was enough water in the tubes to prevent them from drying out. The portions above the water were nearly black. Some gas production occurred in these tubes.

MILK

Fresh, centrifuged milk was filtered through two thicknesses of Schleicher and Schull filter paper and 10 c.c. used in each tube. It had a reaction of between +10 and +15 Fuller's scale. A small coagulum formed in 24 hours after inoculation at 30° C. This was not visible on looking at the tube, but when the milk was poured out it appeared as a small soft lump. In

48 hours the milk was entirely coagulated and showed some signs of separation; in four days this was quite complete, but the curd continued to shrink for several days longer. The action of the milk was slower at 20° or 37° C., coagulation at either temperature not occurring until the fourth day. Such tubes at 37° as were not coagulated within four days time did not coagulate later. After five to seven days at 20° and 25° C. small bubbles of gas were evolved when the tubes were disturbed. No evidence of curd digestion was seen.

Viability in milk. In order to test the duration of viability, transfers to tubes of sterile broth were made from cultures on milk at the end of each 10 days, 15 days, 22 days, and 36 days. Growth was secured in every case. All transfers from such tubes which had been incubated during this period showed strong clouding after 24 hours at 25° C., while those from tubes at 37° C. showed only slight clouding after 24 hours. (For acid and gas production in milk see later discussion of biochemical characters, pages 394 and 400).

Litmus milk. Tubes of litmus milk were made up by adding to ordinary milk, when ready for tubing, 0.1% azolitmin. Tubes of this milk were not entirely coagulated until three days after inoculation, showing a slight retardation as a result of the addition. Acid production was evident two days after inoculation. This became more marked until the fifth day, and at this time reduction of the litmus began. This proceeded rather slowly until it was complete in 20 to 30 days. Tubes at the higher temperature of 30° C. showed a return of the neutral lavender color in 40 to 60 days. Inoculated tubes of this litmus milk and of ordinary milk were titred at the end of 45 days and found to have a reaction of +75 to +85 Fuller's scale, showing that the return of color was not associated with any decrease in acid content. Otherwise these tubes behaved in the same manner as did the tubes of ordinary milk.

FERMENTATION BROTHS

Using the standard beef as a base, fermentation broths were prepared containing 2% additions respectively of saccharose, lactose, maltose, dextrose, mannite, glycerin, urea and asparagin. These media were put up in uniform fermentation tubes having a height of about 15.5 cm. in diameter of 1.3 cm. and a well marked constriction between the open and closed arms. Twenty c.c. of broth was placed in each tube. The work with all of the broths, except urea, was repeated three times, using eight tubes of the same medium in each series; that with the urea was repeated only twice. Inoculations in these tubes were made simply in the surface of the open arm. These trials indicated the organism to be a faculative anaerobe, since the stronger growth always occurred in the open arm, but in practically every case some growth was made in the closed arm. In no case did any gas form. The details of the trials follow:

Saccharose. Growth at 30° C. was very good in the open arm in 24 hours, with slight growth in the closed arm. At from 48 hours to five days there was marked difference in the growths in the open and closed arm, the growth being much the stronger in the former. This difference remained more or less apparent in cultures as old as 20 days, but growth in the closed arm was quite good in five days. In a week there was a small amount of granular sediment, which continued to increase until the tubes were 20 days old, when the closed arm had become almost clear. At 37° C. a fair clouding occurred in both the open and closed arms within 24 hours, the latter becoming almost clear in five to seven days, with a slight amount of sediment.

Lactose. The growth was very similar to that in saccharose, but at 30° C. the difference between open and closed arm was more marked. The growth was somewhat stronger, and more sediment formed.

Maltose. The growth was similar to that upon saccharose but the difference in growth in the closed and open arms remained quite marked in tubes 20 days old.

Dextrose. The growth was very similar to that on saccharose but with less marked difference between the growth in the open and closed arms.

Mannite. A much stronger growth in the closed arm was observed than in any of the preceding broths. There was, however, in cultures two to three days old but slight difference between the open and closed arm. Clearing in the closed arm at 30° C. began in about eight days and was almost finished in fifteen days. Tubes at 37° C. were almost entirely clear after five days, but a small amount of sediment remaining.

Glycerin. A strong growth occurred in the open arm, but the closed arm remained perfectly clear in almost every case. Where slight clouding in the closed arm did occur, it seemed due to the slight circulation of the broth caused by handling the tubes. The growth in the open arm and connecting tube was so dense as to give the broth a milky appearance. At 30° C. the tubes had only begun to show signs of clearing in 15 days, while at 37° they were nearly cleared in 10 days.

Urea. This was a very unsatisfactory medium, for upon sterilization by flowing steam a clouding and slight precipitation ensued, doubtless indicating some change in the medium. In no case was a good growth secured. It was slight and, because of the natural clouding, it was uncertain whether growth occurred in the closed arm or not. It ensued in the open arm, and a line showed the difference in clouding between the open arm and the closed arm. The broth was almost clear in 10 days at 30° C., and a small amount of sediment developed.

Asparagin. The growth was good, and fairly well marked differences were observed between the growth in the open and the closed arms. The clouding developed in the closed arm which was very pronounced in three to eight days at 30° C., though possibly not quite so strong as in mannite. The growth in the open arm was stronger than in any of the other broths, save perhaps glycerin. A large amount of flocculent sediment formed at the base of the closed arm and in the constriction leading into the open arm in about five days. This did not increase much, but its texture became finer in about seven days, forming a somewhat compact mass. The closed arm began to clear in 7 to 8 days at 30° C., and in 15 days was almost entirely clear.

BLOOD SERUM

Stroke cultures on this medium showed good growth in 24 hours at 30° C. It was effuse with a slight tendency to be umbilicate in elevation. The edges were strongly echinulate, the surface slightly contoured, and the growth glistening and slimy. A very pronounced milky clouding occurred in the condensation water, but there was no increase in its amount as the growth progressed. The substratum, which was quite cloudy at first, became clear in cultures ten to fifteen days old. There was slow but distinct liquefaction.

STARCH JELLY

Starch jelly was made as follows: 7 c.c tubes of the fluid medium used were heated to from 65° to 70° C., and to each was added .7 grams of pure potato starch and the mixture thoroughly stirred with a glass rod. The tubes were then immediately placed slanting in a water bath at 80° to 90° C.[1] The tubes were then sterilized by heating for two hours on each of 6 consecutive days at 80° to 90° C., in a water bath in which beakers of water were placed to maintain a moist atmosphere.

Starch jelly in Fermi's solution. The growth was very good. It was a trifle too wide for a typical filiform growth, had echinulate edges, umbilicate elevation, was more or less contoured, glistening, very slightly viscid, light yellow, and did not cloud or discolor the medium.

---

[1] Careful attention to the temperature is essential to success in making this medium. If the temperature of the liquid is too high when the starch is added, swelling begins so promptly that the starch forms a thick mass, which clings to the stirring rod and cannot be properly mixed with the liquid. If, on the other hand, the temperature is too low, the starch settles before swelling begins. When the temperature is properly regulated a homogeneous jelly is secured.

Starch jelly in beef broth. Cultures showed a good growth but not as strong a one as that which formed upon the starch jelly in Fermi's solution. There was no viscidity, the color was almost white, and no clouding or discoloration of the medium was observed.

SILICATE JELLY

This medium was prepared as follows: C. P. hydrochloric acid was diluted with distilled water to a specific gravity of 1.1 at 15.5° C. A solution of sodium silicate was diluted with distilled water to a specific gravity of 1.085 at 15.5° C. Collodion sacks were made by pouring a 5% solution of collodion into a large test tube, (size about 3x25 cm.), rotating the tube meantime, and, when sufficient had been added so that there was about 2 or 3 cm. of fluid in the bottom of the tube, at once pouring this out, rotating the tube constantly. It was then allowed to drain bottom up for two to three minutes, the excess collodion wiped from the lip of the tube, and the tube rotated in front of an electric fan for 5 to 8 minutes. The tubes were then filled with water, the top portion of the collodion sack separated from the test tube, and the entire sack carefully withdrawn. These were then placed in distilled water until wanted. Equal parts of the sodium silicate and hydrochloric acid were measured out, and the sodium silicate added by permitting it to drop rapidly into the acid, stirring thoroughly meanwhile. This solution was then poured into collodion sacks, each sack receiving about 70 c.c. The mouths of the sacks were fastened firmly with rubber bands, they were immersed in running water and permitted to dialyze for 12 hours. They were then taken out, the silicate jelly poured into a flask and boiled for two or three minutes. In the meantime some Fermi's solution was made up, using only one-tenth as much water as the formula calls for. The air was exhausted from this solution in a vacuum chamber, the silicate jelly was cooled down to about 40° C. and the Fermi's solution added. It was then carefully mixed, tubed, slanted and at once sterilized under 8 pounds of steam pressure.

The growth upon this medium was very abundant in 48 hours. It was filiform but somewhat inclined to be spreading, with echinulate edges, glistening, slightly contoured, umbilicate in elevation and slimy. The condensation water was very milky. The growth was grayish white, translucent-opalescent, and after 5 days it showed a slight viscosity and a very slight greenish-yellow discoloration of that portion of the medium forming the slant. In about 8 days small rib-like out-growths appeared on the under surface of the stroke, which in 10 to 15 days frequently appeared to have formed on the mid-rib a tooth-like growth. (See figure 13). The medium was somewhat inclined to split, and wherever such splitting occurred the organism quickly appeared as a heavy growth. The amount of growth continued to increase visibly until the cultures were at least a week old and was more abundant upon this than upon any other solid medium.

FERMI'S SOLUTION

The growth was quite strong with ring formation in 6 to 7 days at 30° C. The clouding in the medium was very persistent and the amount of sediment considerable. In some cases the ring extended out over the surface of the medium to some extent, but not sufficiently to be termed a pellicle. This ring was very easily broken up and most of it settled to the bottom of the tube. In six weeks time the white precipitate in the tubes was 10 to 12 m.m. deep. The tubes at 37° C. became almost entirely clear in 12 days, only a moderate amount of sediment remaining.

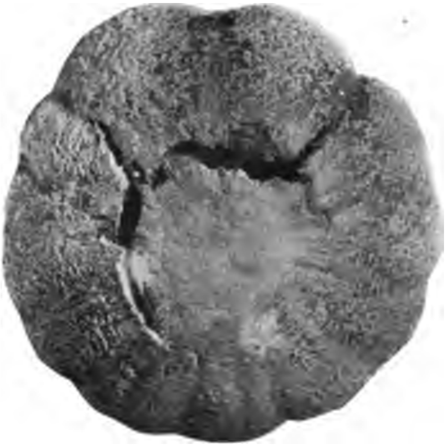


FIGURE 1. Montreal melon showing infection in a natural crack.

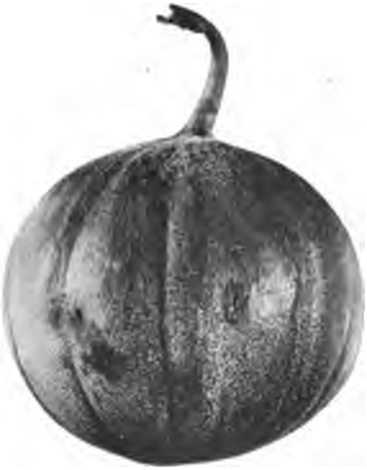


FIGURE 2. Montreal melon showing early stage of rot, at spot just at right of center, 24 hours after needle prick inoculation with a pure culture of *Bacillus melonis*.

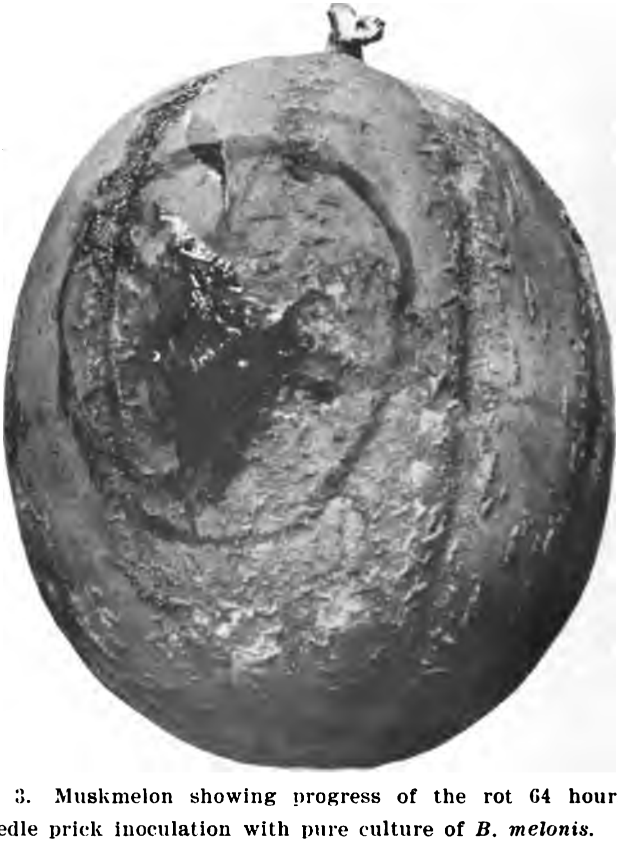


FIGURE 3. Muskmelon showing progress of the rot 64 hours after needle prick inoculation with pure culture of *B. melonis*.

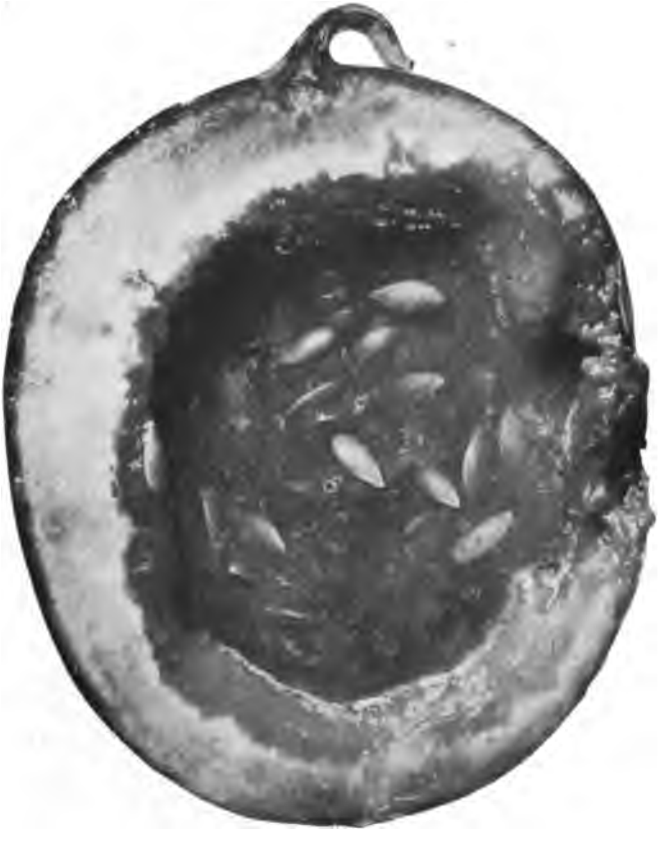


FIGURE 4. Showing same melon as Figure 3, cut open, lengthwise. The flesh was completely rotted on the right side in the neighborhood of the inoculation, the interior cavity was fully invaded and the rot was progressing through the flesh on all sides as shown by the darkened margin.

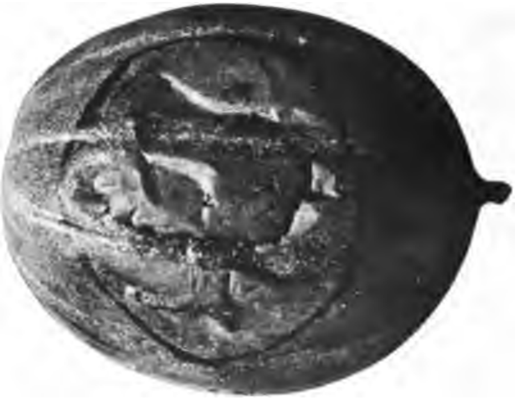


FIGURE 5. Muskmelon 38 hours after needle stab inoculation with pure culture of *B. melonis*. Fully one-third of the visible surface was then rotted, as outlined by the ink line encircling it.

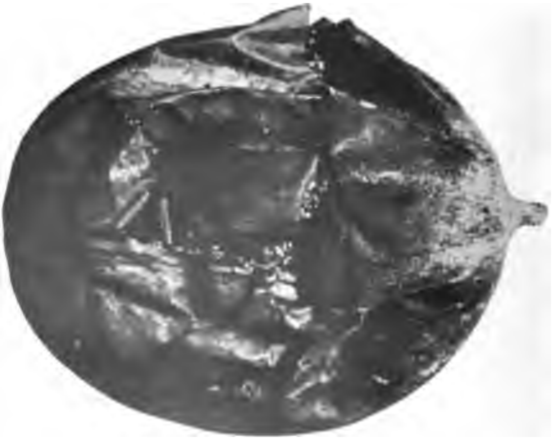


FIGURE 6. Same melon 65 hours after inoculation

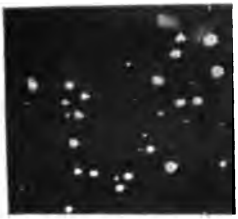


FIGURE 7. Agar plate colonies of *B. melonis*, 3 days growth at 25° C. Natural size.

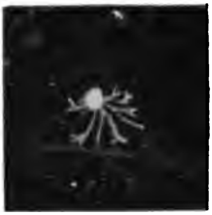
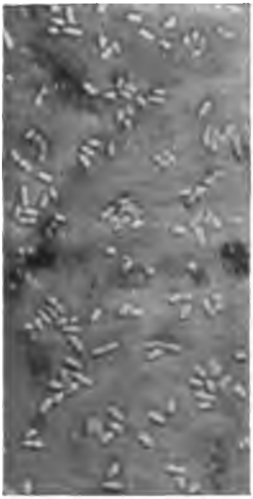


FIGURE 8. Agar plate colony of same age showing spreading type associated with abundant moisture.



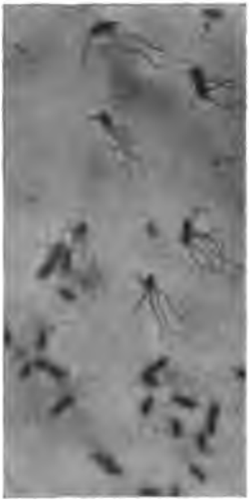


FIGURE 9. Photomicrograph of *B. melonis* showing living organisms in agar hanging block culture, × 1350 (Zeiss ½ obj., ocular No. 4).

FIGURE 10. Photomicrograph under same lenses showing 10 micron divisions of stage micrometer.

FIGURE 11. Photomicrograph of *B. melonis* with flagella stained by Löwitz method, × 1350.

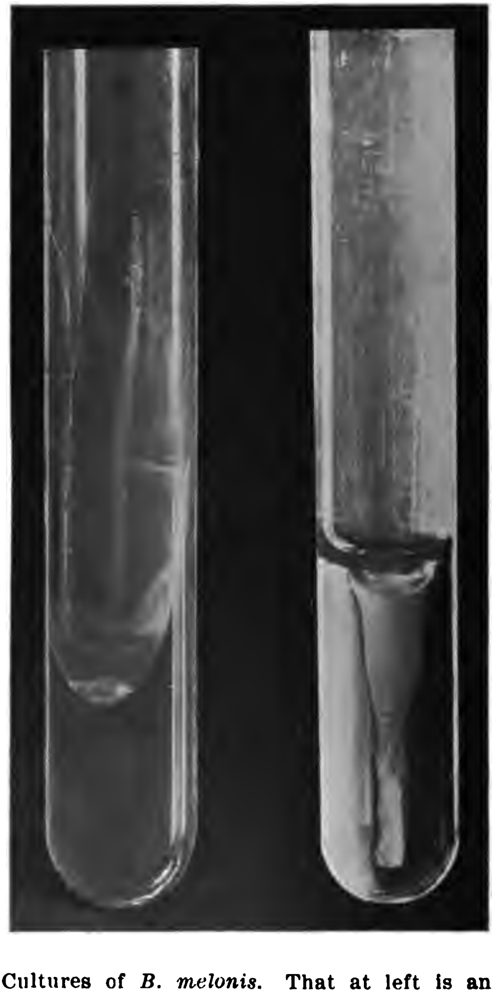


FIGURE 12. Cultures of *B. melonis*. That at left is an agar stroke culture 3 days old 30° C. That at right is a gelatin stab culture, 75 hours growth at 20° C.

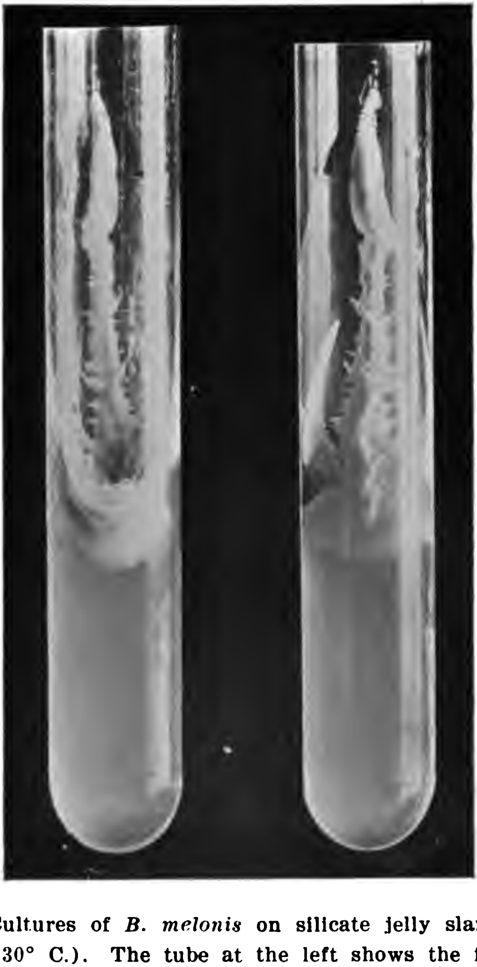


FIGURE 13. Cultures of *B. melonis* on silicate jelly slants, 12 days' growth, (30° C.). The tube at the left shows the face or front view. The tube at the right shows the same seen from the back, i. e., looking through the medium.

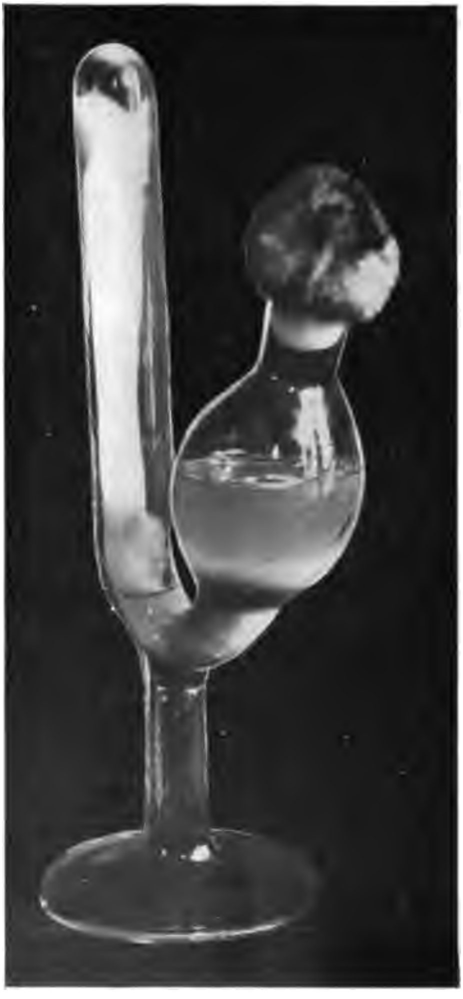


FIGURE 14. Fermentation tube culture of *B. melonis* in milk, 13 days old. Note that the closed arm of the tube is fully occupied by gas, except for the column of shrunken curd.

USCHINSKY'S SOLUTION

A good growth occurred with strong clouding in 24 hours. This increased until the end of the second or third day and remained undiminished at the end of 12 to 15 days. There was a pronounced ring and pellicle formation. The pellicle broke up readily upon slight disturbance of the tube, and in a large measure sank to the bottom. In 10 to 15 days this appeared to be somewhat viscid, not breaking up readily upon shaking. The medium was not viscid. There was a disagreeable odor from the tubes suggestive of hydrogen sulphid.[1] The growth in this medium was more pronounced than upon any other fluid medium, unless it was asparagin broth.

COHN'S SOLUTION

Cultures made upon this medium gave no growth.

SPECIAL MEDIA[2]

A. *Whey medium.* Good growth occurred in the closed arm in fermentation tubes within 24 to 48 hours. The clouding increased until the end of the sixth or seventh day and then seemed to decrease. Much sediment formed in the connecting arm. Growth in the open arm was slightly better than in the closed arm in cultures one to two days old.

B. *Curd medium.* Fermentation tubes showed slight clouding in the closed arm 24 hours after inoculation, and fairly well marked clouding in 48 hours. This almost disappeared in 10 days. The curd in the open arm not covered by water was somewhat decomposed by the organism.

C. *Curd medium with lactose.* There was moderate clouding in the closed arm in fermentation tubes at the end of 48 hours.

D. *Casein medium with mannite.* This medium, which had a bluish white appearance when inoculated, at the end of 48 hours was pure white. The change seemed to be as marked in the closed as in the open arm. It coagulated in four or five days. There was slight separation in the tubes in 7 days, the fluid after separation of the curd remaining clear. The amount of separation, however, was slight even at the end of 15 days.

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[1] See in this connection page 407.

[2] The composition and methods of making these special media are discussed later in connection with the physical and biochemical characters of the organism on pages 402 and 403.

E. *Casein medium.* No visible change occurred in the fermentation tubes until 10 to 12 days after inoculation. The medium at that time was somewhat whiter than in the checks. It is naturally quite milky so that slight clouding would not have been noticed.

PHYSICAL AND BIOCHEMICAL CHARACTERS

TEMPERATURE RELATIONS

Maximum temperature. Peptonized beef bouillon having a reaction of +15 was clouded within five hours at 44° C., when inoculated from bouillon cultures. No growth occurred in this medium at 47° C., and after six hours' exposure at this temperature the bouillon was not clouded at room temperature.

Minimum temperature. Peptonized beef bouillon having a reaction of +15 was clouded in 14 to 21 days at 1° C. The minimum temperature would, therefore, appear to be about 0° C.

Growth at different temperatures. The optimum temperature for growth is about 30° C., but very good growth was secured at laboratory temperature, 22° to 25° C. In all of the work so far as practicable four different temperatures were used. One thermostat was held at 18 to 20°; one at 24° to 25°; one at 30°; and one at 37.5°. The best growth was secured in the 30° thermostat. At 37.5° there was always a slight growth and on some media a fair growth at first, but all clouding due to growth generally disappeared within a few days. At 25° a quite pronounced clouding of broth occurred in 24 hours; at 20° the same amount of clouding was not apparent until after 48 hours.

Thermal death point. In determining the thermal death point, transfers were made from broth cultures 1 to 3 days old into tubes of nearly uniform diameter, 14 cm. ×1.5 cm., having a wall about .8 mm. thick and which contained 10 c.c. of nutrient broth, having a reaction of +10 Fuller's scale. These inoculated tubes were allowed to stand a short time, 30 minutes to an hour and a half, before heating. They were then heated in a large water bath by immersing the tubes for at least four-fifths of their length in water, which was held at the desired temperature by a very large calcium chlorid thermo-regulator, and was kept constantly in circulation by a small agitator operated by a motor. This combination of stirrer and thermo-regulator held the desired temperature within 0.1° C. The temperature inside the tubes was noted at intervals of 2 minutes during these exposures. It was found to average about as follows:

Temperature of water during 10 minutes exposure	Temperature inside tubes after immersion for:		
	2 minutes	4 minutes	6 minutes
45	43.2	44.5	44.9
46	44.4	45.6	45.9
47	45.6	46.8	46.9
48	46.5	47.4	48.9
49	47.4	48.9	48.9
50	48.3	49.9	49.9
51	49.5	50.9	50.9

Two accurate thermometers were used, one being kept in the water bath all the time, while the other was placed in a 10 c.c. tube of the medium used, with the bulb nearly at the bottom of the tube and cotton placed around the thermometer at the top of the tube. In trials conducted in this way, the organism was in all cases killed by ten minutes' heating in the bath at 50° C.; in a few cases the cultures were killed at 49° C. The growth was retarded somewhat at 47° and very decidedly at 49°. Immersion at 45° did not perceptibly retard growth.

GROWTH IN CARBON DIOXID

Two tubes of freshly steamed milk, azolitmin milk, agar stab, agar stroke, gelatin stab, broth and Uschinsky's solution were inoculated and placed at once in a Novy jar. Carbon dioxid from a Kipp generator was passed through a 10% solution of sodium carbonate, a 10% solution of potassium permanganate, freshly boiled distilled water, and then into the Novy jar. The gas was allowed to pass through the jar rather rapidly for an hour; the jar was then closed and sealed. It remained closed for 12 days. Upon opening no sign of growth was found upon any of the media, except for a slight trace in the gelatin and the agar stabs. The tubes were placed in an incubator at 25° C., and in 24 hours there was good growth in broth, agar stab, agar stroke, and gelatin stab with liquefaction of the gelatin.

INDOL PRODUCTION

Cultures were made in Dunham's peptone solution and in the 1 percent solution recommended by the American Public Health Association.

Cultures 10 days old gave a slight rose color, indicating indol production. This reaction was somewhat more pronounced at 37° C. than at the other temperatures, and was more pronounced in all the tubes after warming at 70° C. for about five minutes. There was very little difference in the reaction of the two broths, but the indol production in the 1% peptone seemed to be a little stronger than in the other. The tubes were tested at the end of 20 days and well marked indol reaction was secured in the Dunham's solution after the tubes were allowed to stand for a few moments. In the 1% peptone there was a fair reaction upon standing, but not apparently much more than in the 10 day old cultures. The indol test was made by adding to the tubes about 5 to 10 drops of C. P. sulphuric acid, allowing the tubes to stand a few moments, and then adding to each tube 1 c.c. of a .01% solution of sodium nitrite. There was no indication that nitrites were produced since the reaction was secured only when the sodium nitrite was added. Check tubes of the solution gave a slight brownish reaction, which was quite different from the rose red reaction secured in the cultures.

NITRITE PRODUCTION

Nitrates were reduced to nitrites upon each of the following media: (A) 1 liter of water, 2.5 grams Liebig's extract of beef, 3 grams C. P. potassium nitrate, 10 grams Witte's peptone. (B) 1 liter of distilled water, 1 gram Witte's peptone, and 1 gram C. P. potassium nitrite. (American Public Health Association). The presence of nitrites was determined by the starch iodine method. Cultures of A 5 days old showed strong nitrite production, while cultures of B at the same age showed very slight bluish discoloration, after standing 15 to 20 minutes. Tests were also made at the end of 10 days, at which time the tubes of B incubated at 37° gave a fairly well marked reaction within 2 to 3 minutes. Tubes of B incubated at other temperatures showed a more pronounced reaction than the 5 day old cultures, but it was quite slow in appearing. Tubes of A gave as strongly marked reaction at the end of five days as at the end of 10 days.

AMMONIA PRODUCTION

The ammonia production was determined by distillation of the culture, or of the uninoculated material, in a liter flask with heavy magnesium oxid, collecting the distillate in a small flask containing a known amount N/20 hydrochloric acid. The distillation was continued for about 30 minutes and the distillate titred with N/20 hydrochloric acid or sodium hydroxid as was required, using cochineal as an indicator.

Cultures were made in 500 c.c flasks containing, respectively, 100 c.c, of nutrient broth, nutrient gelatin or milk. When these cultures were 10 days old they were distilled and the ammonia in the distillate determined. Control distillations were also made on 100 c.c. samples, both of uninoculated milk and broth. The results secured showed that there was no ammonia production in any of the above mentioned media, since the amount of ammonia secured from the checks was as large as the amount secured from the cultures.

Distillation was also made of broth from fermentation tube cultures of urea and asparagin. From 100 c.c. of asparagin broth, taken from fermentation tubes 2 days after inoculation, sufficient ammonia was secured by distillation to neutralize 5.25 c.c. of N/1 hydrochloric acid. The same amount of broth from the cultures 4 days old required 16.3 c.c. of N/1 hydrochloric acid to neutralize the distillate. Thirty-five c.c. of uninoculated asparagin broth required about 2.8 c.c. of N/20 hydrochloric acid to neutralize the distillate. The amount required for the uninoculated asparagin broth was about the same as that for uninoculated nutrient broth, showing that the only ammonia secured from the check distillation of asparagin broth was what would have come from the nutrient broth itself. The organism evidently broke down the asparagin, forming large quantities of ammonia in so doing.

Material from fermentation tube cultures of urea was also distilled. One hundred c.c. of urea broth from 2 days old cultures required 3.9 c.c. of N/1 hydrochloric acid, 4 days old cultures required 3.8 c.c., 15 days old cultures required 4 c.c. and 40 c.c. of uninoculated broth required 1.6 c.c. From this it is evident that ammonia was secured from the urea as well as from the nutrient broth in the uninoculated material, and that there was no ammonia produced by the organism through breaking down of the urea. There was also evidence of slight alkali production in fermentation tubes of maltose 18 days after inoculation, however, as will be noted in the table showing titrations of that broth. No distillations were made.

ACID PRODUCTION

Acid production was determined upon milk, litmus milk, and various fermentation broths. The latter were made by adding to nutrient broth 2% of either maltose, lactose, saccharose, dextrose, glycerin, urea, asparagin or mannite. The acid production in milk was far more pronounced than in any of the other media tested. Litmus milk was reddened in 2 days. The greatest amounts of acid were produced in the fermentation broths carrying saccharose, lactose and dextrose. Tubes of maltose showed very slight acid production at the end of 4 days, and at the end of 18 days showed slight alkali production. There is some question whether the large amount of acid in milk arises from the fermentation of the lactose, or of some other compound found in the milk. A more detailed discussion of this milk fermentation will be found under the head of gas production. A tabular summary of the acid production on milk and upon various fermentation broths is given on pages 396-399. The results secured with asparagin broth are omitted, since a large number of titrations, both from inoculated and control tubes, indicated that a chemical reaction occurred between the asparagin and the sodium hydroxid making the neutralization point somewhat obscure. Titrations were made with N/20 sodium hydroxid, using phenolphthalein as an indicator. Five c.c. samples were taken from each tube of the fermentation broths. The entire quantity of milk, 10 c.c., was used in the case of these cultures, and the tubes were carefully rinsed with some of the water used in making the dilutions. The sample in each case was diluted with 45 c.c. of distilled water and was boiled 2 to 4 minutes to drive off carbon dioxid.

EXPLANATION OF TABLES

The first column gives age of the culture when titred; the second column, the temperatures at which the cultures were incubated; the double column headed "First series" gives the reactions expressed in degrees of acidity on Fuller's scale of one set of cultures, duplicate cultures being titred in most cases; the double column headed "Second series" gives the reactions, similarly expressed, of another set of cultures; and the single column to the right gives the average reaction for all tubes at any given age and temperature, and the average reaction of all control tubes.

ACID PRODUCTION IN MILK

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	17.2	18.5	12.9	13.7	15.6
	25 “	19.3	21.2	14.5	13.2	17.6
	30 “	19.9**	21.7**	17.1**	18.0**	19.2
	37 “	19.6	18.0	10.7	11.2	14.9
2 days	20 “	18.5	19.1	13.8	14.4	16.5
	25 “	18.9	20.5*	16.4*	16.6*	18.1
	30 “	32.3*	20.2*	19.6*	20.2*	20.6
	37 “	18.8	19.3	12.1	12.1	15.6
4 days	20 “	18.3*	18.9*	17.0*	16.6*	17.7
	25 “	18.4*	20.6*	23.5*	16.8*	19.8
	30 “	23.0*	25.3*	26.6*	27.1*	25.5
	37 “	23.5	24.3	16.0	12.7*	19.1
10 days	20 “	21.9*	21.5*	19.7*	15.9*	19.8
	25 “	38.6*	41.4*	36.0*	34.1*	37.5
	30 “	42.5*	46.6*	46.4*	46.5*	45.5
	37 “	26.8	27.8	31.2*	21.5	26.8
21 days	20 “	53.8*	48.3*	47.0*	49.5*	49.7
	25 “	57.3*	58.2*	59.0*	62.2*	59.2
	30 “	54.2*	45.9*	52.8*	54.5*	51.9
	37 “	23.8	25.4	29.0*	34.6*	28.2
	Controls	15.4	15.1	10.1	10.1	12.9
		15.7	14.6	10.6	11.5	....
		15.5	16.1	10.6	9.5	....
		14.6	15.4	11.7	10.4	....
		15.5	15.1	10.5	10.8	....

A single star following the figures for any tube indicates that the milk was entirely coagulated. Double stars indicate that portions of the milk had so coagulated that a lump was noticed when it was poured out.

ACID PRODUCTION IN MALTOSE

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	15.0	15.2	16.7	....	15.6
	25 “	20.3	20.3	14.9	14.4	17.5
	30 “	21.9	21.1	16.6	17.2	19.2
	37 “	15.9	15.7	12.7	....	14.8
2 days	20 “	18.0	17.5	12.7	....	16.1
	25 “	13.1	14.7	12.5	13.5	13.5
	30 “	13.7	15.9	11.4	11.8	13.2
	37 “	14.1	14.8	11.1	....	13.3
4 days	20 “	14.3	12.8	14.2	....	13.8
	25 “	12.7	11.5	14.7	12.2	12.8
	30 “	12.9	14.1	18.4	16.6	15.5
	37 “	16.0	16.6	20.0	....	17.5
18 days	20 “	....	....	7.3	....	7.3
	25 “	....	....	6.7	9.5	8.1
	30 “	....	....	4.7	2.7	3.7
	37 “	....	....	34.8	....	34.8
	Controls	14.2	12.6	10.2	12.0	12.3

ACID PRODUCTION IN SACCHAROSE

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	14.0	13.1	13.4	....	13.5
	25 "	18.0	17.5	13.5	15.0	16.0
	30 "	19.6	20.0	15.2	15.2	17.5
	37 "	14.9	12.4	10.1	....	12.5
2 days	20 "	19.1	17.9	14.0	....	17.0
	25 "	20.7	20.1	17.5	15.7	18.5
	30 "	20.4	20.2	17.4	18.0	19.0
	37 "	11.5	10.9	13.7	....	12.0
4 days	20 "	21.1	20.8	17.8	....	19.9
	25 "	21.1	20.6	18.1	17.7	19.4
	30 "	21.9	22.7	19.5	21.2	21.3
	37 "	14.6	14.3	23.0	....	17.3
18 days	20 "	....	....	18.0	....	18.0
	25 "	....	....	19.6	....	19.6
	30 "	....	....	20.5	21.4	21.0
	37 "	....	....	27.5	....	27.5
	Controls	11.7	11.3	8.5	10.0	10.4

ACID PRODUCTION IN LACTOSE

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	10.4	10.4	8.4	....	9.7
	25 "	18.6	12.4	11.1	11.8	13.5
	30 "	18.8	17.6	13.4	12.1	15.5
	37 "	12.6	12.3	8.9	....	11.3
2 days	20 "	14.5	13.5	12.8	....	13.6
	25 "	18.1	18.1	13.8	14.0	16.0
	30 "	22.2	23.5	13.5	13.8	18.3
	37 "	11.0	10.4	11.8	....	11.1
4 days	20 "	18.6	19.7	14.8	....	17.7
	25 "	22.0	20.0	14.5	15.3	18.0
	30 "	19.2	18.1	16.8	17.6	17.9
	37 "	13.9	14.0	20.5	....	16.1
18 days	20 "	....	....	14.7	....	14.7
	25 "	....	....	17.8	17.0	17.4
	30 "	....	....	19.5	18.8	19.2
	37 "	....	....	22.8	....	22.8
	Controls	10.6	11.0	10.0	9.0	10.2

ACID PRODUCTION IN DEXTROSE

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	10.4	11.0	14.8	....	12.1
	25 "	18.1	17.5	15.7	13.9	16.3
	30 "	19.0	19.1	16.2	14.8	17.3
	37 "	14.9	14.4	12.0	....	13.8
2 days	20 "	14.4	13.7	13.4	....	13.8
	25 "	16.2	19.1	14.9	13.6	16.0
	30 "	22.0	21.5	17.5	18.4	19.9
	37 "	11.7	11.9	16.0	....	13.2
4 days	20 "	17.0	18.8	17.8	....	17.9
	25 "	17.8	23.0	18.8	19.2	19.7
	30 "	24.6	25.1	20.8	22.3	23.2
	37 "	13.6	13.4	29.5	....	18.8
18 days	20 "	....	....	13.7	....	13.7
	25 "	....	....	19.9	17.5	18.7
	30 "	....	....	21.5	19.6	20.6
	37 "	....	....	29.4	....	29.4
	Controls	10.9	11.3	10.0	10.0	10.6

ACID PRODUCTION IN GLYCERIN

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	9.2	10.2	8.2	....	9.2
	25 "	9.7	9.6	8.8	8.5	9.1
	30 "	10.9	11.0	8.7	8.8	9.9
	37 "	13.0	12.1	10.0	....	11.7
2 days	20 "	10.0	10.4	8.5	....	9.6
	25 "	10.6	11.7	10.3	10.3	10.7
	30 "	11.3	11.0	9.0	9.5	10.2
	37 "	11.3	10.7	11.3	....	11.1
4 days	20 "	11.0	10.4	8.3	....	9.9
	25 "	11.3	11.6	11.0	13.0	11.7
	30 "	12.0	11.8	10.2	10.9	11.2
	37 "	13.2	12.9	10.0	....	12.0
18 days	20 "	16.1	14.0	....	....	15.1
	25 "	16.6	....	....	....	16.6
	30 "	15.1	15.6	....	....	15.4
	37 "	19.2	18.0	....	....	18.6
	Controls	9.5	10.0	8.1	8.2	9.0

ACID PRODUCTION IN MANNITE

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	14.4	13.4	10.2	....	12.7
	25 “	16.6	14.8	13.4	18.0	14.5
	30 “	17.0	16.6	14.0	14.4	15.5
	37 “	10.4	10.8	14.3	....	11.8
2 days	20 “	16.6	17.2	13.5	....	15.8
	25 “	15.9	17.0	13.8	13.6	15.1
	30 “	15.4	17.3	13.2	13.2	14.8
	37 “	20.6	19.9	16.5	....	19.0
4 days	20 “	15.3	16.9	15.2	....	15.9
	25 “	15.1	16.2	16.2	18.0	16.4
	30 “	16.4	18.4	17.2	15.7	16.9
	37 “	22.6	21.1	16.8	....	20.2
15 days	30 “	16.2	17.0	....	....	16.6
	25 “	17.5	18.0	....	....	17.8
	30 “	20.0	21.2	....	....	20.6
	37 “	25.0	25.2	....	....	25.1
	Controls	9.2	9.6	8.0	8.5	8.8

ACID PRODUCTION IN UREA

Age	Temperature	Acidity expressed in degrees of Fuller's scale				
		First series		Second series		Average
1 day	20°C.	15.9	16.2	10.0	....	14.0
	25 “	11.4	10.7	10.7	10.3	10.8
	30 “	8.7	8.2	10.4	9.1	9.1
	37 “	12.8	11.7	10.0	....	11.5
2 days	20 “	11.8	11.2	8.6	....	10.5
	25 “	9.0	10.3	8.7	8.8	9.2
	30 “	12.6	11.6	9.7	10.5	11.1
	37 “	11.2	9.2	9.0	....	9.8
4 days	20 “	10.8	9.7	9.5	....	10.0
	25 “	9.8	7.9	11.3	11.7	10.2
	30 “	12.6	13.1	9.4	9.5	11.1
	37 “	9.0	10.4	9.8	....	9.7
15 days	20 “	12.0	11.5	....	....	11.8
	25 “	12.4	....	....	....	12.4
	30 “	12.3	13.3	....	....	12.8
	37 “	13.8	16.3	....	....	15.1
	Controls	9.8	10.0	9.8	9.2	9.7

GAS PRODUCTION

Cultures were made in fermentation tubes of nutrient broth containing 2% additions, respectively, of lactose, maltose, dextrose, saccharose, glycerin, asparagin, urea, and mannite. In order to secure convincing data the entire series was run three times, except urea, which was run only twice. In each trial, a total of 8 tubes of each medium were used, two tubes being carried at each of the four temperatures, 20°, 25°, 30°, 37° C. There was no sign of gas production in any of these tubes, except in two out of six of the asparagin tubes at 30° C. and one out of six of the asparagin tubes at 25°. Two of these three asparagin tubes produced only 5% gas, and the other tube only 8%. This gas was tested as carefully as possible without special apparatus, and found to be about half carbon dioxid. The residue was thought to be nitrogen, since no explosion or ignition could be secured.

Comparison with B. coli. For purposes of comparison inoculations of *Bacillus coli,* taken as a type of actively fermentative bacteria, were made into fermentation tubes containing nutrient broth and 2% additions of saccharose, dextrose, lactose, maltose, glycerin, asparagin or mannite. Gas production occurred in these cultures of *B. coli* amounting to about 70% in mannite, 28% in maltose, 28% in dextrose, 25% in lactose, 6% in glycerin. No gas production appeared in asparagin or saccharose.

Shaken cultures were also made in agars containing either 2% or 5% of lactose, saccharose, dextrose, glycerin, mannite or plain nutrient agar. No gas production appeared in any of these cultures. Cultures of *B. coli* were made upon each of the above media at the same time, and abundant gas production occurred in all such, save those upon plain nutrient agar.

Gas from milk. When the preliminary cultural characters were observed in the fall of 1907, it was noted that gas was produced in tubes of milk and litmus milk after they were a week to 10 days old, and that none was secured in nutrient agar containing lactose, saccharose, or dextrose. In the course of the final studies it was further noted that no gas was produced in fermentation tubes of nutrient broth containing these various carbohydrates. The gas produced in tubes of milk was quite noticeable, especially if the tubes remained undisturbed for 3 or 4 days after they were about a week old. In such cases, if the tube was gently rapped, many small and some large bubbles would rise to the top of the whey. This phenomenon seemed so strange that fermentation tubes of milk were prepared, sterilized, and inoculated in the same manner as ordinary tubes of milk. In the course of 6 to 15 days a small amount of gas gathered in the top of the closed arm of all such tubes. After this gas production began it proceeded quite rapidly, completely filling the closed arm in 4 to 6 days. In many cases it was noted, after the closed arm filled, bubbles of gas continued to escape from it through the open arm. These trials with fermentation tubes of milk have been repeated several times, including, all told, some 75 tubes, and like results were secured in every case. The gas produced was tested by shaking with a 2% solution of sodium hydroxid and found to be more than 99% carbon dioxid. The small portion of gas not absorbed was tested as carefully as might be and appeared to be nitrogen. Owing to the difficulty of testing so small a bubble, the method followed in the earlier trials was to collect the small bubbles from 3 or 4 tubes into one small tube, the transfer being made under water. This gas thus collected in the one tube was then carefully brought into contact with an open flame by forcing it slowly out of one end of the tube, which was held in the edge of the gas flame. No explosion or ignition took place. An eudiometer tube was secured for use in later trials, and the small bubbles from two tubes were collected over mercury. The pressure on this gas was then bought up to normal by the ordinary levelling device, the amount noted, oxygen in excess of the amount required to form water added, atmospheric pressure again restored, and the total amount again noted. The mixture of gases was then sparked, but no explosion or diminution in volume took place. A quantity of hydrogen, slightly greater than the amount of the unknown gas, was added, and the mixture of gases again sparked. This time an explosion ensued, and the volume diminished proportionately to the water value of the added hydrogen. Repetition afforded exactly similar results. It was therefore concluded that the small bubble remaining in the fermentation tubes after the absorption of carbon dioxid was not hydrogen.

Special media. The amount and composition of the gas produced from milk was so striking that the following special media were made up in order to see if further light might be secured.

A. *Whey medium.* Freshly centrifuged milk, amphoteric to neutral litmus, was secured, and to 200 c.c. was added .01 c.c. of rennet. This was allowed to stand at a temperature of about 40° C. for 2.5 hours. At the end of an hour the milk was coagulated, and at the end of 2.5 hours the whey and curd were partially separated. The milk was then placed in an Arnold sterilizer and heated at 99° C. for 10 minutes. This seemed to make the coagulum firmer and force out more of the whey. The latter was then carefully poured out on a filter, as much being secured from the curd as was practicable without squeezing it or removing it from the flask. This filtered whey was then put up in fermentation tubes and sterilized by flowing steam. Inoculated tubes of this medium showed gas production in six to seven days at 25° C. The amount of gas produced was from 30% to 54% of the closed arm, and its analysis afforded results similar to those secured with the gas from milk in that 99% thereof consisted of carbon dioxid.

B. *Curd medium.* The curd remaining after the removal of the whey, used in making the above medium A, was washed thoroughly four times with distilled water by shaking it vigorously and allowing it to stand 10 or 15 minutes before pouring off the water. The curd was then forced into the closed arm of large fermentation tubes, using distilled water to aid in getting it into its location, and to occupy the larger portion of the space. This medium was sterilized in a steamer, inoculated and incubated in the same manner as with A. At the end of 15 days there was no sign of gas production in any of the tubes.

C. *Curd medium with lactose.* Sufficient lactose was added to the distilled water in two of the fermentation tubes containing curd to make a 4% solution. Inoculated tubes of this medium showed a small bubble of gas in the closed arm at the end of 4 days. This amount had not increased at the end of 15 days, and was considered too small to be tested with any apparatus available at that time.

D. *Casein medium with mannite.* In making this medium 100 c.c. of a saturated solution of calcium hydroxid was used as a solvent for 3 grams of Eimer and Amend's C. P. casein. This stood for about eight hours with frequent stirring, then .05 grams di-potassium acid phosphate (K^2HPO^4) was added. The mixture was stirred and allowed to stand over night. A small amount of casein did not go into solution, so it was warmed, filtered, and 2 grams C. P. mannite added to the filtrate, which was then put into fermentation tubes and sterilized by flowing steam. The growth in this medium was very good as may be noted under cultural characters, but there was no sign of gas production in any of the tubes at the end of 30 days.

E. *Casein medium.* This medium was similar to D and made up in the same manner, except that commercial casein, precipitated by sulphuric acid, was used and that no mannite was added. A considerably smaller portion of this casein appeared to go into the solution than of the C. P. casein, but the solution had a slightly more milky appearance than did the other. There was no sign of gas production in any of these tubes.

Milk analyses. It was suggested that gas might be produced in the closed arm in fermentation tubes in the absence of oxygen. In order to test this idea, fermentation tubes of freshly centrifuged milk reacting +12 on Fuller's scale were inoculated, and placed in an atmosphere of carbon dioxid. Some of these tubes were inoculated five days, and some one day previous to placing in a Novy jar, while others were freshly steamed and, as soon as cool, inoculated and placed at once in a Novy jar. These tubes were the ones mentioned in the earlier discussion of growth in carbon dioxid (page 391). No gas had been produced in any of these tubes when the jar was opened at the end of 17 days. The cultures were then placed in an incubator at 25° C. and gas was formed in all the tubes by the end of seven days. The results attained in these trials would indicate that the gas produced in the fermentation tubes of milk was not due to the breaking down of the casein by the organism. With the hope of securing further information along this line determinations were made of the protein, lactose and acidity contents of samples of the culture medium. A quantity of fresh, centrifuged milk was secured and placed in 200 c.c. portions into 300 c.c. Erlenmeyer flasks. An analysis of a single sample was made at once, and the other portions were sterilized by flowing steam at 99° C. for fifteen minutes on each of three consecutive days. One-half of the flasks were then inoculated by adding to each with a sterile pipette 1 c.c. of a 24 to 48 hour broth culture. The inoculated and control flasks were then incubated at 25° C., and one of each taken out for analysis every third day up to and including 15 days after inoculation.

The results of these analyses are given in the following table:

Age of sample	Control samples			Inoculated samples		
	Protein	Milk sugar	Acidity	Protein	Milk sugar	Acidity
Fresh milk	3.81%	4.40%	0.155%	....	....	....
3 days	3.83	4.30	0.16	3.97%	4.20%	0.16%
6 days	3.90	4.15	0.17	3.77	3.25	0.18
9 days	3.73	3.70	0.16	3.93	2.40	0.18
12 days	3.78	3.60	0.17	3.80	2.09	0.18
15 days	3.93	3.40	0.17	4.02	0.69	0.44

The only thing about the control samples which was thought worthy of special note was the continual diminution of lactose content as age increased. There was practically no change in acidity to account for such diminution and no attempt at explanation will be made here.

The lactose content of the inoculated samples shows a remarkable decrease of 3.51% in twelve days. By deducting from this amount the total diminution of the lactose, 0.90%, noted in the control tubes during the same period, there remained for the inoculated samples a loss of 2.61%, which may be considered as directly due to the activities of this organism. The total gain in acidity of the inoculated samples during the twelve days was 0.28%. Assuming that the organism produced but one molecule of lactic acid from each molecule of lactose, the loss in lactose, 2.61%, was greatly in excess of the amount which would be required to account for this gain in acidity.

The gas produced in the inoculation flasks was very slight on the ninth day, but was quite pronounced on the twelfth day, and appeared to be fully as strong on the fifteenth day.

These results, showing practically no change in the protein content and an excessive loss in the lactose content, with the greater portion of this loss taking place when abundant gas production is occurring, would indicate that the carbon dioxid is formed as a result of fermentation of the milk sugar.

ALCOHOL PRODUCTION

It has been suggested that this organism produced a yeast-like fermentation of lactose. All of the work completed up to this point would indicate that such was the case. As alcohol is one of the products of yeast fermentation of sugar, an endeavor was made to determine whether or not alcohol was produced in milk fermented by this bacillus. For this purpose 500 c.c. of fresh centrifuged milk was placed in a 750 c.c. Jena flask and sterilized by flowing steam at 99° for fifteen minutes on each of three consecutive days. This milk was then inoculated with 3 c.c. of a 24-48 hour broth culture, and left at room temperature, 20-20°. At the end of fifteen days the culture was poured into a larger flask and distilled until about 50 c.c. of distillate was secured. A portion of this distillate was tested as follows: Four or five drops of a 10% solution of potassium hydroxid was added, the mixture warmed to about 50° C., and a solution of potassium iodide saturated with free iodine added, a drop at a time, until the liquid assumed a permanent yellowish brown color. It was then carefully decolorized by adding, drop by drop, more of the potassium hydroxid solution, and set aside. The fluid gave off a distinct odor of iodoform and in a few moments, there was an abundant deposit of yellow crystals in the bottom of the tube. The results of this test would indicate the presence of an alcohol, acetone, or aldehyde in the distillate. This test was repeated with a second portion of the filtrate, and similar results secured, although in this case the formation of several iodoform crystals was noted before the mixture was entirely cleared by the addition of potassium hydroxid. In the absence of a good direct test for so small an amount of alcohol, the following tests, as outlined in Allen's Commercial Organic Analysis, vol 1, were carefully made for the presence of aldehydes: The resinous deposit with sodium hydroxid, the silver mirror with ammoniacal silver nitrate, and the color reaction with excess of phenol-sulphonic acid. Negative results were secured in every case, indicating that there was no aldehyde present. These determinations seemed to warrant the statement that the fermentation of milk caused by this organism results in the production of alcohol.

A careful search has served to reveal but a single instance[1] of a bacterial fermentation of milk which resembles the one above recorded. No analysis of the gas was made in this case, but the author states that the greater part thereof was carbon dioxid.

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[1] Leichmann, Dr. G., "Ueber die freiwillige Sauerung der Milch." Centbl. f. Bakt. Parasit. u. Inkektionskr. 2. Abt., II: 777 (1896).

Mandel[1] mentions a fermentation of lactose which results at the outset in the production of galactose and dextrose which sugars may then undergo alcoholic fermentation. The initial step of this fermentation is spoken of as taking place quite slowly and, since the gaseous fermentation of milk by this organism was quite late in appearing, it was thought that the milk fermentation which it produced might be of such character. The time available for this work did not permit of the testing of a galactose broth, but some interesting results might be secured from such trials.

HYDROGEN SULPHID PRODUCTION

In determining the production of this gas, strips of absorbent paper moistened with a solution of lead acetate were placed in the tubes, so that the end of the strip hung down nearly to the top of the culture. These strips were remoistened daily with distilled water. The end of the strip inserted in the culture tubes of nutrient broth was decidedly browned, while those hung over the gelatin and cooked potato cultures were slightly tinged. Strips of absorbent paper moistened in the same way were kept in control sterile tubes of the three media used. These gave no indication of browning, showing that the hydrogen sulphid production was caused by the growth of the organism in the culture.

ODOR

There was no very decided or distinctive odor evolved from any of the media. A fairly strong disagreeable odor arose, however, from cultures on raw turnip, raw carrot and cooked potato. The odor from cultures on cooked potato reminded one of decaying potato tubers in a storage cellar.

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[1] Hammarsten-Mandel, "Text Book of Physiological Chemistry," p. 392, (1902).

GROWTH OVER CHLOROFORM

This medium was prepared by adding .05 c.c. of Squibb's "U. S. P." chloroform to 10 c.c. tubes of sterile bouillon and shaking the tubes slightly. The chloroform was added to the broth with a sterile pipette. Tubes of nutrient broth with such additions of chloroform showed good growth in 24 to 48 hours; the growth was perhaps slightly retarded, but not to any great extent as evidenced by the fact that the clouding was somewhat stronger in the upper part than in the lower part nearer the chloroform.

TOLERATIONS

Oxalic acid. Growth was secured in +15 peptonized beef bouillon, acidified to +45 and +47 with oxalic acid. No growth was secured in a similar medium acidified to +52 with oxalic acid.

Malic acid. Growth was secured in +15 peptonized beef bouillon, acidified to +37 with malic acid.

Sodium chlorid. Bouillon free from sodium chlorid was taken as the basal medium, and the salt was added thereunto to make a series containing, respectively, 1, 2, 3, etc. to 10%. A very good growth ensued in 24 hours in the several media containing from 1 to 6%. A slight growth appeared in 24 hours in that containing 7% and, at the end of 48 hours, a fair growth therein, as well as a very slight growth in that containing 8%. This did not perceptibly increase. No growth having appeared after ten days in the 9 and 10% tubes, transfers were made therefrom and they were found to be sterile.

Hydrochloric acid. Ordinary beef bouillon, having a reaction of zero Fuller's scale, was used. Sufficient N/1 hydrochloric acid was added to 100 c.c. of the bouillon to secure reactions of +5, +10, and so on, taking every 5 degrees Fuller's scale up to +50. A very good growth ensued in 24 hours in the medium having a reaction of +20. At the end of 48 hours a good growth was secured in the medium having a reaction of +20, and very slight growth in that having a reaction of +25. The growth in the +25 medium became slightly stronger at the end of ten days, but otherwise there was no change. No signs of growth appeared in any of the media containing a larger amount of acid.

Sodium hydroxid. 100 c.c. portions of ordinary beef bouillon, having a reaction of zero Fuller's scale, were measured out and to each was added the theoretical amount of N/1 sodium hydroxid requisite to secure reactions of —5, —10, and so on for every 5 degrees of Fuller's scale up to —45. Tubes of these media were inoculated and placed in the incubator at 25° C. These showed good growth in 24 hours at 0, fair growth at —5, and slight growth at —10. In 48 hours there was good growth in —5 and —10, fair growth in —15, slight growth in —20. In three days there was good growth in —15, fair growth in —20, slight growth in —25. In five days there was good growth in —20 and —25, fair growth in —30, slight growth in —35. The growth in —35 increased slightly at the end of 20 days, but there was no sign of growth in any of the tubes containing a larger amount of alkali. Sterile control tubes of this broth put up to be —35, —30, and —25, were titrated at the end of 20 days and found to afford a reaction ranging from —14 to —19. This indicated that the sodium hydroxid present when the broth was put up and inoculated had been largely, if not entirely, changed to sodium carbonate. It was, therefore, thought best to repeat the trials keeping the cultures in a carbon dioxid free atmosphere. Tubes of media put up like those above mentioned but ranging in reaction from zero to —30 were inoculated and placed with check tubes in Novy jars. The air was then drawn through, the jars being washed in two bottles of 12% solution potassium hydroxid, a bottle of 1% sulphuric acid, and a bottle of distilled water before reaching the Novy jars. The air was drawn slowly through the jars for about 2 hours, the jars were then carefully sealed, and left at the room temperature 20 to 25°. After 12 days the jars were opened and growth was found in tubes put up to be 0, —5, —10 and —15 Fuller's scale. The growth in the —15 broth was slight and it was only fair in the —10 broth. There was no sign of growth in the —20 broth. Transfers were made from inoculated —15 to —20 broths to tubes of ordinary broth and good growth was secured in tubes from the former, while no sign of growth was obtained in tubes from —20 broth.

Titrations of the control tubes of —10, —15, and —20 broth, made immediately after taking them from the jars, showed them to have reactions of —5, —7.4, and —10.2 respectively. It was, therefore, concluded that the organism was unable to withstand an alkalinity of —10.2 Fuller's scale with sodium hydroxid.

EFFECT OF GERMICIDES

The only germicides tried were phenol and formalin. These germicides, previously diluted with sterile distilled water, were added to tubes of sterile bouillon, using sterile pipettes.

Phenol. Media were used containing .78%, .44%, .18%, .11%, .09%, .08%, .05% and .02% of Merck's "U. S. P." phenol crystals. At the end of 24 hours good growth occurred in the .02% phenol, slight growth in the .05% and the .08% phenols, but no indications of growth in any of the others. In 48 hours fair growth appeared in the .05 and .08% and very slight growth in the .09% and .11%. This growth did not appear to have increased any in 10 days. There was no sign of growth in the media containing respectively, .18%, .44%, and .78% of phenol. After 15 days transfers were made from these tubes to tubes of nutrient broth. Growth was secured in transfers from all inoculated tubes containing .02%, .05%, .08% and .09%, and from three tubes containing .11%. There was no sign of growth from the other two tubes containing .11%, or from any tubes containing a greater amount of phenol.

Formalin. Media were used containing .43%, .24%, .10%, .05%, .04%, .02%, .01% and .005% of Bausch and Lomb's

40% formalin. In 24 hours good growth occurred in the .005% and very slight growth in the .01% and .02% trials. In 2 days a fair growth was found in the .01% and slight growth in the .02% and very slight growth in the .04%. There was no increase of growth noted in these tubes in 10 days. There was no signs of growth in media containing .05%, .10%, .24%, or .43%. Transfers from these tubes were made in the same manner as from the phenol tubes. Growth was secured from all tubes containing .005%, .01%, and .02, and from two tubes containing .04%. There was no sign of growth from the other two tubes containing .04%, or from any tubes containing a larger percentage of formalin.

DESICCATION

Straight needle transfers were made from 24 to 48 hour old broth cultures to sterile cover·slips in sterile petri dishes. Care was taken to get as little of the broth as possible from the cover slips, and it was carefully spread out in a very thin film, frequently invisible. These were then allowed to dry down at room temperature, i. e. 20 to 25° C. In order to test the viability of the organisms under such circumstances, six of these covers were transferred with sterile forceps to broth tubes at the end of each 5 minutes, 15 minutes, 30 minutes, 3 hours, 8 hours, 16 hours, 24 hours, 68 hours, and 7 days. Good growth was secured in tubes containing cover slips which had been dried out up to and including 68 hours, but the growth in those dried for 68 hours was quite slow in appearing, showing no sign of growth until 48 hours after transferring the cover slips to the broth. Cover slips dried for 7 days were sterile.

INSOLATION

Agar plates were poured having a dilution such that the plates had from 200 to 300 colonies. These were allowed to incubate for about a half hour. One-half of each plate was then covered, the plates laid on a tray of snow to prevent overheating, and then exposed to the direct rays of the sun. These exposures were made between half past one and half past two o'clock, Nov. 21, 1908. A part of the plates were exposed for 15 minutes, others for an hour. These plates were then incubated at 25° C. At the end of 48 hours it was found that the ones exposed for one hour had no colonies on the exposed side and averaged 106 colonies on the covered side. The ones exposed 15 minutes averaged 19 colonies on the exposed side and 68 colonies on the covered side.

REMEDIAL MEASURES

Detailed studies of this organism, which are given in the previous pages, show that it is capable of development as a wound parasite upon several hosts, but especially upon muskmelons. Its behavior in cultures indicated that it could live indefinitely as a saprophyte under favorable conditions.

No opportunity was offered in the course of these studies to determine experimentally what might be done to check the disease when it was once started in the field. Of course any remedial measures must aim at prevention rather than cure, and must therefore be taken before the disease becomes widespread. Spraying with bordeaux mixture is to be commended as a general preventive of this and related melon diseases. Supporting the melons on stones or otherwise to keep them from contact with the soil, and occasional turning will doubtless give better results than can be secured in any other way. Whenever practicable, irrigation should be practised in a dry time to insure uniform and continuous growth and to avoid cracking of the fruit. Diseased melons in a field should be immediately removed and destroyed, and the crop should be carefully watched for the first appearance of the rot, in order to keep the organisms from the field as much as possible, since the disease may readily be carried from one melon to another by insects. A field in which the rot has been seriously prevalent should not be used the next year for the growth of melons. An interval of at least three years should intervene between melon crops in such cases. Rotting melons should not be thrown on the compost heap, or be fed to stock, or else, in case this is done, such compost or manure from such animals should not be used on melon fields.

It is probable that little trouble will be experienced during a season which is continuously dry. If, however, the entire season is unusually wet, or if heavy rains follow a dry period, the danger is increased. Under such conditions especial care should be exercised in spraying with bordeaux mixture, and in so supporting and turning the melons as to keep all sides exposed to light and air as much as practicable. The disease, once started in a wet field where no such precautions are taken, spreads very rapidly; and a melon once infected is lost.

BRIEF DESCRIPTION OF BACILLUS MELONIS N. SP.[1]

A careful study of the organism described in this paper, and a comparison of its characters with those of other vegetable soft rots, seem to justify its recognition as a distinct species. We are, therefore, proposing for it the name *Bacillus melonis* (new species). The following may be regarded as its most important differential characters:

A bacillus .6-.9 by 1-1.7, actively motile by means of 4-6 peritrichic flagella. Endospores not produced and organisms not stained by Gram's method.

Nutrient broth. Strong clouding in 24 hours; no pellicle or ring formation; slight sediment.

Agar stroke. Abundant, slightly spreading, contoured, slimy, glistening, translucent, opalescent growth having umbilicate elevation.

Agar stab. Filiform growth.

Agar plate. Colonies round or amoeboid.

---

[1] Descriptions based on cultures incubated at 30° C., unless otherwise noted.

Gelatin stab at 20° C. Infundibuliform liquefaction in two days.

Cooked potato. Growth abundant, spreading and glistening.

Milk. Coagulation and some separation in two days; acid production of +55 in twenty-one days; abundant gas production in 10 to 18 days at 25° C.; gas 99% carbon dioxid, the remainder non-explosive with oxygen.

Fermentation broths. Good growth in saccharose, lactose, maltose, dextrose, mannite, glycerin, and asparagin; slight growth in urea; good growth in closed arm in mannite, saccharose and asparagin; no growth in closed arm in glycerin and urea; slight alkali production in maltose after 18 days; slight gas production in asparagin in some cases.

Blood serum. Slow but distinct liquefaction.

Fermi's solution. Strong persistent clouding, ring formation and considerable sediment.

Uschinsky's solution. Strong growth; ring and pellicle formation; considerable sediment; odor of hydrogen sulphid.

Fermi's solution solidified with silicate jelly. Very abundant growth, slightly spreading and contoured; umbilicate elevation; echinulate edges; slight greenish yellow discoloration of substratum.

Cohn's solution. No growth.

Nitrite production. Abundant.

Indol production. Slight.

Ammonia production. Abundant from fermentation tube cultures of asparagin broth. None from nutrient broth, gelatin, milk or urea.

Toleration of sodium chlorid. An addition of 7% required to inhibit growth.

Thermal relations: Optimum temperature about 30° C.
Maximum temperature about 44.5° C.
Minimum temperature about 0° C.
Death point 49 to 50° C.

Vegetables rotted. Muskmelon, citron, carrot, potato, beet, and turnip.

Following the numerical system of recording characters as outlined on the descriptive chart of the Society of American Bacteriologists, endorsed Dec. 31, 1907, the group number of this organism is B. 221,2223032.

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UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 149

JANUARY, 1910

A Practicable Method of Killing Witch Grass

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Free Press Printing Co.,
1910

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***In cooperation with Bu. An. Ind., U. S. Dept. Agr.**

BULLETIN 149: A PRACTICABLE METHOD OF KILLING WITCH GRASS

By A. J. Eaton and H. A. Edson

INTRODUCTION

Witch grass or quack grass (*Agropyron repens*) is one of the worst weeds, by many deemed the worst, found in Vermont tillage areas. The combat therewith is difficult but not impossible. It is costly, but less so than to permit its unrestricted growth. A year or more ago the Station learned that a Windsor county farmer had succeeded in practically eradicating it from his farm by the employment of a special system of soil tillage or cultivation which was essentially the product of his own observations. After consulting with him as to his procedure, arrangements were made with him to employ it upon several neighboring farms with a view of determining its applicability to divers types of soil. This work was carried on during the past season. This bulletin outlines the results of these trials carried on with Mr. A. J. Eaton of South Royalton, the deviser of the method, which the writer deems may well be termed the "Eatonization" of witch grass. In the cases under review the season's work has resulted in almost annihilating the pest on the trial plots, and in producing enough corn, over and above that grown on the untreated areas, to pay in some cases the entire cost of the extra labor involved. The complete eradication of the weed often involves two successive seasons' work, the second of which is of the same character as the first, only less expensive and laborious.

The writer of this note has assembled and co-ordinated the contributions of Mr. Eaton, who tells his own story, of the station bacteriologist, who had the general oversight of the season's work and who took all the field data, and of the Station chemist, who contributes the analytical results.

Joseph L. Hills,
Director.

SUMMARY.

Witch grass may be eradicted from fields, no matter how seriously infested, by the following procedure:

1. Ridging the rows just before the corn sprouts, using a disc hoe or any other tool which makes a ridge over the row. (Figure 1.)
2. Cultivating three days later with a five-toothed cultivator, or a heavy two horse hoe, carrying side hoes, (such as potato hilling hoes turned backwards), drawing the soil away from the sides of the ridges previously made, so that the subsequent harrowing can more effectively level them. (Figures 2, 4, 5.)
3. Harrowing or weeding (preferably the former) the same day. (Figures 3, 6.)
4. Cultivating twice thoroughly, a week or ten days later. (Figures 4, 5.)
5. Weeding the same day, still further levelling the ridges and improving the soil mulch. (Figure 6.)
6. Cultivating thoroughly and shallow every week or ten days thereafter, so long as it can be done without injuring the crop, the oftener the better.
7. Hand hoeing in mid-July.

This procedure will perhaps not absolutely eradicate all witch grass in the corn hills; but it will so nearly do this as to make the next year's combat relatively a pastime. Pages 423-429.

These special tillage operations give the corn crop a serious temporary setback. Not infrequently they kill out a considerable proportion of the infant crop. That which is left, however, is freed from the necessity of fighting for plant food and moisture, and is apt to be larger than the crop on the untreated area. Pages 429-430.

On four trial plots, located respectively on a stony upland loam, a river bottom sandy loam, an upland clay loam, and an almost clear sand, the witch grass was in all cases almost entirely killed out. (Figures 9-16.)

The corn crops grown on the treated as compared with the untreated areas were:

On the stony loam; two and one-fourth tons larger; extra cost of treatment, $2.40 per ton.

On the river bottom sandy loam; one and five-eights tons larger; extra cost of treatment, $5.50 per ton.

On the clay loam; four and three-fourths tons larger; extra cost of treatment, $1.10 per ton.

On the sand; three-fourths of a ton larger; extra cost of treatment, $7.30 per ton. Pages 430-443.

The ears grown on the treated areas as compared with those grown on the untreated areas were larger and better filled out, and both ears and stover were notably richer in protein. In short, a larger crop of higher feeding value resulted; and the witch grass was killed out as well. (Figure 19.) Pages 443-444.

The witch grass is killed out by persistence, by hindering its rooting, by rotting and exposing to the sun the roots and root stalks, and by preventing it from making leaf. The increased corn crop is to be ascribed to the beneficial effects of tillage and to the elimination of weed competition. Pages 446-447.

INCEPTION OF THE METHOD

Several years ago one of the writers (A. J. E.) planted a field of potatoes on witch grass sod. The season was very dry, and, between the dry weather and the witch grass, the potato crop was almost a failure. The field was plowed in the fall and planted to corn the following spring; but in spite of thorough harrowing the witch grass made a fine start before the corn came up. When the first corn shoots were pricking through the surface, the disc hoe was run over the field, throwing ridges over the rows and burying both the corn and the witch grass. Three days later, the cultivator was run between these ridges as deeply as possible, and they were then partially leveled with the smoothing harrow. This was followed in a few days by the weeder run crosswise the rows. The corn came up thin and very yellow, with the shoots pointing in every direction. Once a week the field was worked with the cultivator or weeder. The crop appeared to be set back fully ten days by the harsh treatment, but by the last of June it began to gain rapidly. Two hoeings were given by hand, one late in June and another late in July. The entire cost of cultivation and hoeing was $8 per acre. The corn yielded 160 bushels of ears per acre, and the clover, which was sown just before the last cultivation, made a satisfactory crop the following season, while the witch grass was completely killed out. By using various modifications of this method of culture, the writer has succeeded in freeing a large portion of his farm from witch grass (figures 7, 8, 17, 18), and thus far it has never failed to give satisfactory results.

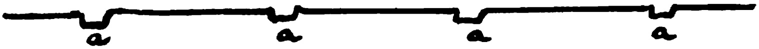
INCEPTION OF THE FIELD TRIALS

The past season's trials were undertaken in cooperation with the Experiment station, at the suggestion of the station botanist, the object being to learn the effect of this treatment upon different soils and under different conditions. In order to secure the variety of soils desired, the experimental plots were necessarily scattered over a considerable area and located at some distance from the home farm. It was not always possible to do the work on them at just such times as it should have been done. Hence the conduct of the project was in some degree unsatisfactory, and the work carried on at a disadvantage. This process cannot be done whenever convenient, but its several successive operations must be carried out, if at all, at the exact times, at the several psychological moments. This statement is particularly true of the initial operation. Some of the plots failed to show as good results as might have been obtained had the work been done more systematically. Yet, notwithstanding, the conclusions that profitable crops of corn can be grown on witch grass sod, and that witch grass can be largely eradicated by one's season's, and entirely killed by two season's, cultivation, were fully sustained.

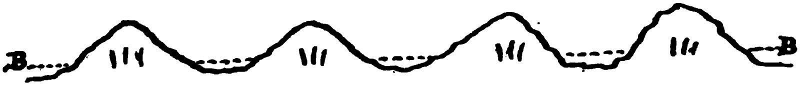
THE SPECIAL TILLAGE PROCESS

The process as at present conducted involves the use of several operations and implements. These may perhaps be best expressed in paragraph form, and illustrated by cross sections of the soil surface as left by the successive operations. Prior to the paragraphation it may be said that the process contemplates the alternate moving of the soil first towards and then away from the row, over and over again. After the first ridging and cultivation, only about two inches of surface soil are moved or in any way disturbed. The general aim is to keep this two-inch mulch so fine and light that nothing can take root in it, and that little soil water can evaporate therefrom. Whatever witch grass or other weed may come up through this mulch is torn out before it gets tough or makes growth enough to do harm. The great advantage which ridging affords is that the cultivator has some thing to work towards. If done properly, not to exceed three inches need be left in the row which the cultivator will not reach, whereas in ordinary cultivation twice as much or more is left untouched by the horse hoe.

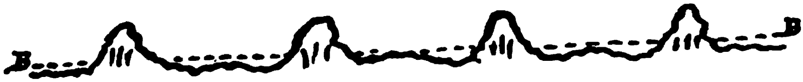
When the corn field is planted, its cross section looks something like the subjoined figure, a representing the mark left by the planter wheel with the corn buried beneath.



(1.) The first step in this special process consists of the ridging of the soil over the rows, using a disc hoe or any suitable tool, this being done before the corn is up, or at the latest just as it is showing its first sprouts above ground. (Figure 1.) This procedure leaves the soil looking in cross section like this, B indicating the former surface level.



(2.) Three days later, a five-toothed cultivator, with side hoes such as are used in hilling potatoes turned backward (figure 5), or two-horse hoe, is run between the ridges (figures 1, 2, 4, 5), drawing the soil away from their sides, so that the subsequent harrowing can more effectually level them. This operation leaves the soil looking in cross section like this, B once more indicating the original surface level.



(3.) On the same day, the small residues of the original ridges, left by the cultivation just described, are leveled with a smoothing harrow (figure 4) or a weeder (figure 6), preferably the former. This treatment leaves a somewhat level surface, as shown at the top of the opposite page:

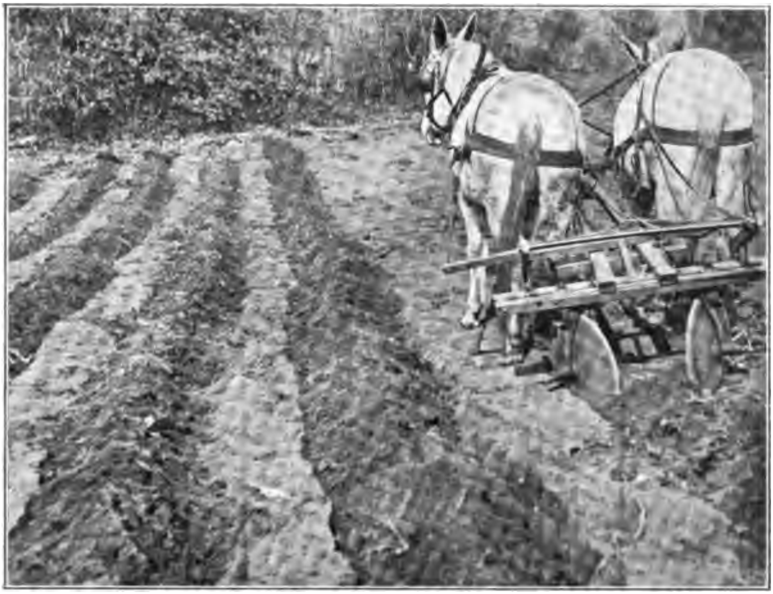


FIGURE 1. Ridging the corn rows, just before or just as the corn sprouts appear. Any tool which makes a ridge over the row may be used. (See text, page 424.)

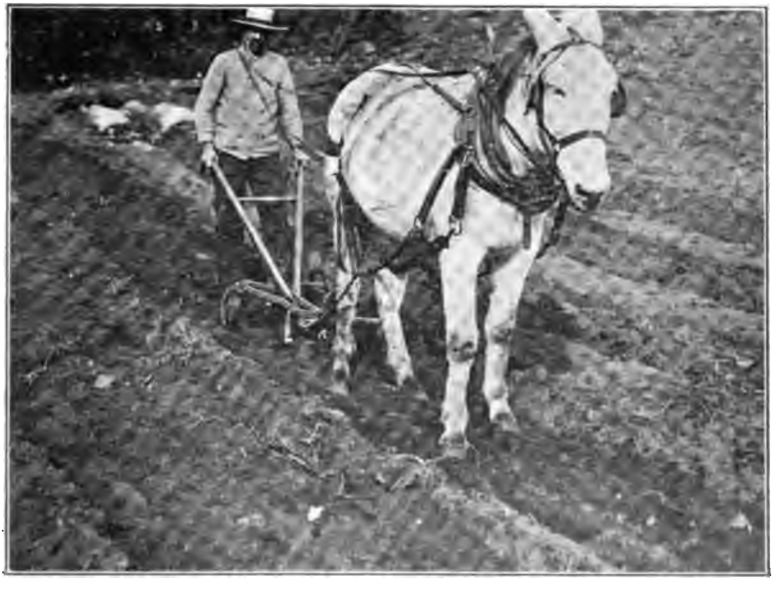


FIGURE 2. Drawing the soil away from the ridges, using a five-toothed cultivator with potato hilling hoes turned backwards, in order that they may move more soil, (illustrated in figure 5; see text, page 424 three days after the operation pictured in figure 1. This operation makes the subsequent harrowing (figure 3) more effective. (See text, page 424.)

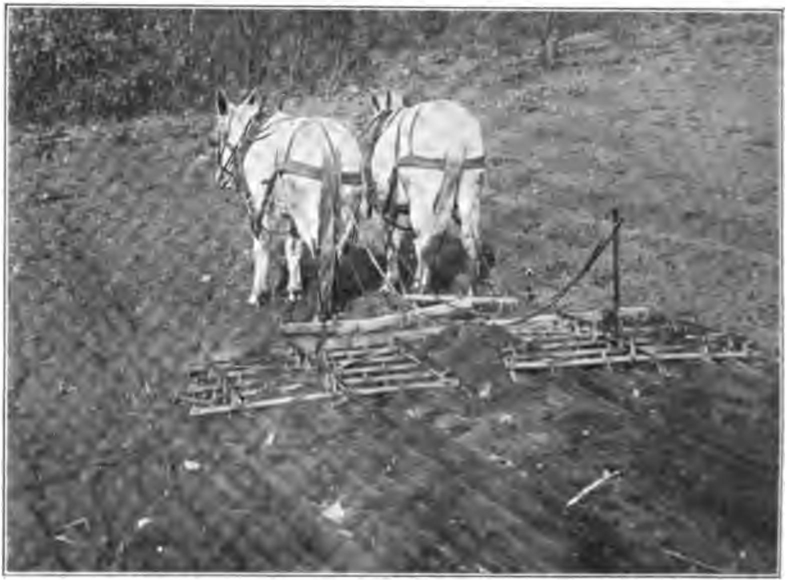


FIGURE 3. Harrowing down and leveling ridges with a smoothing harrow directly after the cultivation (illustrated in figure 2) and on the same day that it is done. If many sods, loose stones, or grass residues exist, crossways harrowing is employed. (See text, page 424.)

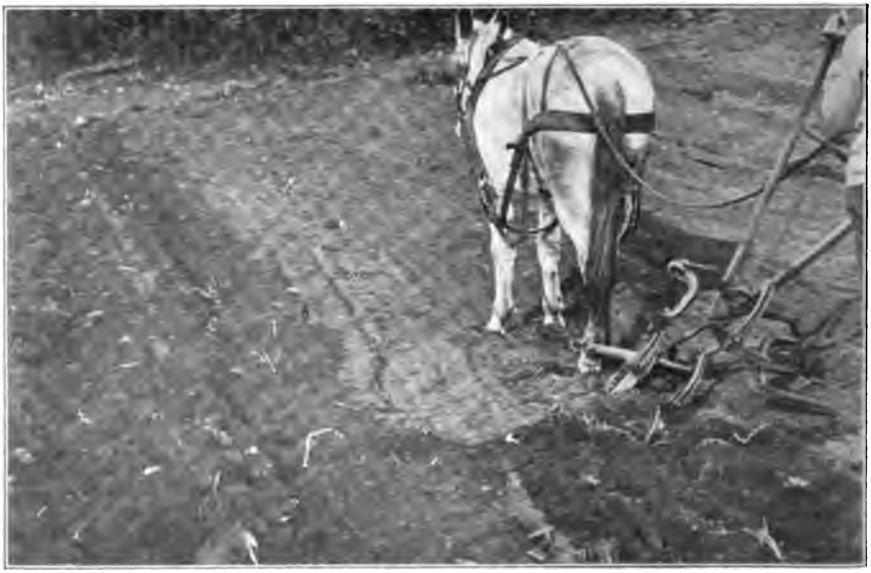
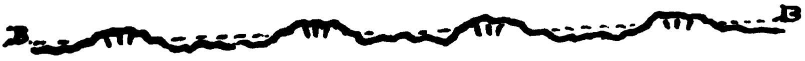
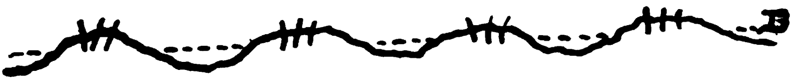


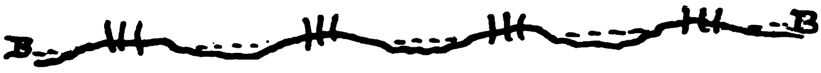
FIGURE 4. Cultivating and thoroughly working the soil towards the ridges, a week or ten days after the leveling process shown in figure 3. Note the side hoes rather dimly shown in cut. The cultivator is raised in order to show the method and place of their attachment. (Figure 5 on opposite page.) (See text, page 425.)



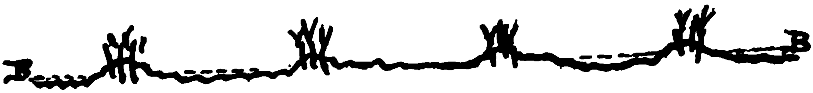
(4.) A week or ten days later, the cultivator is again run over the piece, thoroughly stirring the soil (figures 2, 4, 5). A two-horse riding cultivator will do a more thorough job than will the single-horse mechanism, which commonly needs to be run twice the same day, or in closely succeeding days. The soil now looks like this:



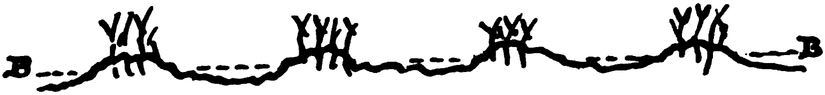
(5.) The same day it is again gone over as in paragraph 3, with smoothing harrow (figure 4) or weeder (figure 6), which serves still more to level ridges and to secure an adequate mulch. The weeder leaves it looking thus:



(6.) Thereafter cultivation as in paragraph 4 is done, thoroughly and shallow, each week or ten days, so long as it can be done without injury to the crop, the oftener the better. This leaves the piece looking thus:



(7.) And, finally, one good hand hoeing is called for in mid-July and the field then looks thus, save that the height of the corn stalks is not properly represented:



The successful conduct of this special process of soil culture and weed killing contemplates the movement in alternation of the surface soil to and from the row, and frequent interference with the rooting habits of the witch grass. The surface soil is first piled on top of the row (figure 1); then, before it smothers the corn, the larger part thereof is spread out between the rows, first by the cultivator with side hoes drawing the soil away from the ridged rows (figure 2), and then by leveling with the smoothing harrow (figure 3). This soil is then thrown back and up towards the rows again (figure 4), and yet again; and, then, almost at once, pulled back again with the weeder run across the rows (figure 5). Further cultivations serve to pile up the soil somewhat in a slight ridge between the rows, and the weeder following not only levels the ridge, but works down the surface of the row slightly. However, the surface of the row is left slightly higher than the area between the rows. This causes the weeder to "take hold" in the row where it is most needed, and permits the cultivator to be run much closer to the corn plants without injury than could otherwise be done.

The subjugation of witch grass in a badly infested field is no child's play by this, or any other, process. It means continuous hard work for both the draft animal and the driver; and, despite the prejudices against mules existing in the minds of many, they possess certain characteristics which fit them especially for this kind of work. They have small feet, a steady gait, are not inclined to fret or hurry, are strong and apparently tireless. They learn quickly—if they want to—and readily become expert at this special task, which, to be thoroughly successful, involves running the cultivator very close to the row. The little mule pictured in figures 1-4 will cultivate from 15 to 20 miles of row daily, regardless of how tough the witch grass may be or how hot the weather, keeping so steady a gait that absolutely perfect work may be done. However, any good horse can do the work; therefore, let no one fail to undertake the task for lack of a mule. But let him understand that entire success depends as much upon the power in front of the cultivator as upon that behind it, although the personality of the man counts for much in the character of the work done. His ability to do the right thing in the right way at the right time is a measurable factor in the successful conduct of the operation.

There is no slight of hand or magic about the process; nothing extraordinary. It is simply the apotheosis of intensive cultivation, specially adapted to a special problem. The initial ridging, and the alternation of the passage of the surface soil back and forwards, towards and away from the rows, are its essential and peculiar features. Emphasis is laid upon the necessity of the continual maintenance of an active fight. It is warfare that is being conducted, with swords beaten into plowshares. One or two operations will not do it. Continual cultivation,—a concept foreign to most farmers' minds,—alone wins the fight. Furthermore, it should be understood that in entering upon this siege against so well entrenched an enemy, one must be prepared to give it first place in one's spring plans. For practical purposes the witch grass field should be the one thing to be attended to, regardless of all else, when the time comes.

The operations, implements, time when the work should be done, and cost, together with references to the illustrations, are expressed in tabular form on the top of the next page.

Operation	Tool	When	Cost per acre[1]	Operation illustrated in
1st. Ridging over rows.	Disc horse hoe	Before or as sprouting.	75 cents.	Figure 1.
2nd. Cultivating between ridges.	Cultivator with side hoes.	Three days later.	50 cts. to $1.	Figures 2, 4, 5.
3rd. Leveling ridges	Smoothing harrow or weeder.	Same day.	25 to 35 cents	Figures 3, 6.
4th. Cultivating twice	Cultivator with side hoes.	Week or ten days later.	$1.	Figures 2, 4, 5.
5th. Weeding	Weeder.	Same day.	25 cents	Figure 6.

THE TILLAGE IMPLEMENTS

No very costly machinery is required. Any tool that will throw the ridge of earth over the corn row without disturbing the sprouting corn will serve the purpose. An ordinary five-toothed cultivator, with side hoes such as are used for hilling potatoes (figures 2, 4) will do the work, although some of the heavy horse hoes are better. The cultivator attachments shown in figure 5 are a great aid to clean cultivation. They can be attached to almost any make of five-toothed cultivator and to nearly all the two-horse riding cultivators. Those shown in figure 5 were made by the manufacturers of the Planet Junior, cost about $1.50, and have done good service for a dozen years. They rapidly dispose of such weeds as Canada thistle, milk weed, wild morning glory, brakes and mallows, if used before the stems become tough and woody. By the persistent working of the soil in alternation away from and towards the row, the surface is kept level, a dust mulch maintained, and all weeds between the rows destroyed. The only one that in the writer's experience has survived this treatment is the common horse tail or scouring rush, which comes up after the corn is too large to allow of adequate cultivation without injury.

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[1] The cost of the actual field work involved in the operations is computed on the basis of allowing $3.50 per ten-hour day for a man and two horses or mules, $2.50 a day for a man with one horse or mule, and $1.75 for a ten-hour day for hand hoeing. These basal figures are used also in the calculations of the handling of untreated plots. (See pages 434 442). In the experimental trials discussed in this bulletin, careful records were kept of the work done on each plot, both treated and untreated, the former by Mr. Eaton, the latter by their respective owners, and the costs, as indicated in the statements on pages 434, 437, 439 and 442, were figured using the prices as above stated.

The exact time at which the ridging may be done to best advantage is not fully determined; but one thing is sure, that if it is done too late the crop will be greatly injured by the harrow. There is more danger of it being done too late than too early. Probably two or three days before the first corn shoots prick through the surface, or from five to eight days from planting, is about the right time; but additional data needs to be gathered regarding this and some other points. Incidentally it may be remarked that on soil which is free from witch grass, a light ridge three or four inches high, thrown over the row before the corn is up and worked down with a weeder, is a decided help to clean culture, and, likewise, tends to prevent crows from pulling the corn.

THE TEMPORARY SETBACK OF THE CORN CROP

The employment of this process of witch grass eradication gives the corn crop at the outset a serious, though temporary, setback. A considerable proportion of the infant crop is often killed at birth. Thus, for example, in the trials about to be discussed, one-fifth of the young crop was killed out on two of the plots, which were ridged ten days from planting, too late for effective work, and one-sixth on the third; whereas upon the clay loam soil, ridged only five days after planting, but little damage appeared to be done.[1] The crop looks worse during, and almost to the end of, the first month than does the untreated corn. Until late June the treatment seems to have wrought havoc rather than help; and doubtless many, who may try this method of eradicating witch grass, will declare in June that its adoption spells ruin. But it is confidently predicted that September will tell another story. Unfortunately no photographs were taken in June, showing this temporary untoward condition; but those taken in September, showing the ultimate result, speak for themselves. Stress is laid upon this matter, for inevitably this temporary effect of the harsh treatment will dismay and dishearten many, and perhaps lead them to abandon the process when but partially completed, when, with the corn crop lessened and with witch grass not killed, considerable harm is done and little good accomplished.

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[1] When the exact best time for ridging is determined, it is thought that the loss can be mostly avoided.

For the same reason that it is advisable to run the cultivator in opposite directions in the same row, it is *not* advisable to run the harrow or weeder over the same row twice in opposite directions. When the tender young corn shoots have grown up into these ridges somewhat, the harrow or weeder in passing over the row slants them in one direction. If the harrow or weeder going in the opposite direction strikes this row, not only whole hills but often strips a rod or more in length are taken out clean. Perhaps this result may largely be prevented by ridging earlier, The whole process is very much like running a buzz planer. If the stick slips, one is apt to cut his fingers. After the corn is well up, the weeder may be run in opposite directions or crosswise and do very little harm.

What happens to the witch grass when this method of tillage is employed? In the first place it is buried. Then by frequent stirring the surface soil is kept sufficiently moist so that the witch grass roots and root stalks decay instead of drying out, while those which come to the surface are so continually kept moving that they have little or no opportunity to take root. The first season's work, if adequately carried out, serves to kill almost all the grass and to leave practically only that which is located between the corn plants. A second season's work—easier by far than the initial one—finishes the remainder.

THE EXPERIMENTAL TRIALS

Location of fields. The pieces chosen, four in number, were located in the town of Royalton and were situated on four types of soil:

I. A stony upland loam, at an elevation of about 1,300 feet above sea level, and within a short distance of the memorial monument erected at the birthplace of Joseph Smith the Mormon Prophet. (Plots 1 to 3, figures 9-13.)

II. A river bottom sandy loam in the White River valley between South Royalton and Sharon, located within a stone's throw of the Central Vermont railway track (plates 4 and 5, figures 15-16).

III. A clay loam situated on the upland (plots 6 and 7, figure 17).

IV. A sandy knoll running longitudinally through an upland corn piece (plots 8 and 9).

Choice of location of plots. The owners of the several pieces on which the experimental plots were situated, in each case fertilized, prepared and planted the entire areas in such manner as they pleased. The choice of the plots was not made until the time arrived for the initial procedure, i. e., the ridging of the rows. The primary object of the work being to demonstrate the efficacy of this method of soil culture as a means of exterminating witch grass, care was taken in each case to locate the plot in that portion of the field which seemed worst infested, so be it that ready access thereto was possible. The selection was made, moreover, without reference to the adjoining areas which were later to be used for purposes of comparison, or to the remainder of the piece. These control or untreated plots were selected at the time of the harvest, adjoining the treated plots on one side (plot 2) or on both sides thereof (plots 5, 7 and 9). The several plots were of diverse sizes, as indicated below:

1.	Treated	8 rows	451	feet long
2.	Untreated	2 "	447	"
3.	Untreated	2 "	425	"
4.	Treated	8 "	843	"
5.	Untreated	4 "	843	"
6.	Treated	12 "	43	"
7.	Untreated	12 "	34	"
8.	Treated	10 "	270	"
9.	Untreated	2 "	250½	"

Methods of sampling. The field work involved in sampling the crops at the end of the trials was done by the station bacteriologist, who is well informed as to methods and was scrupulously careful in his work. The sampling and data taking were systematically carried out, and counts and weights were checked by another person. A definite, regular, unvarying proportion of the crop of each of the treated and untreated trial plots was taken. Furthermore, whenever there was the slightest opportunity for doubt or question, it was resolved in favor of the untreated piece. For example, plot 3 (untreated) was chosen at the request of the owner, thus comparing a section representative of the average of the entire field which was untreated with the treated plot, instead of that just adjacent thereunto, which had been chosen for plot 2 (see page 433). Again an irregular strip of somewhat lighter soil, on which the corn growth was much smaller, ran diagonally across plots 4 and 5. Relatively a larger proportion of the sample was taken from this strip as it crossed the treated plot than as it crossed the untreated areas on either side, so as to make certain to do the latter (the untreated areas) no injustice. In short, conscientious effort was made by an unbiased expert in sampling to insure accuracy, and to forestall any possibility of successful cavil. Furthermore, the station chemist, in making his check weights on the samples after their arrival at Burlington (they were shipped by express immediately upon cutting, carefully wrapped and protected against loss of moisture, were received at the train on arrival, and at once prepared for analysis), and in subsampling and analysis, knew them by number only and was ignorant as to their identities. And, finally, to clinch the matter, the local photographer was called upon to show the differences in the crops, and the results of his very successful labors are exhibited in figures 9 to 16. The Station is indebted to this gentleman, Mr. W. E. Graham of South Royalton, for his painstaking in accurately portraying the fields and processes.

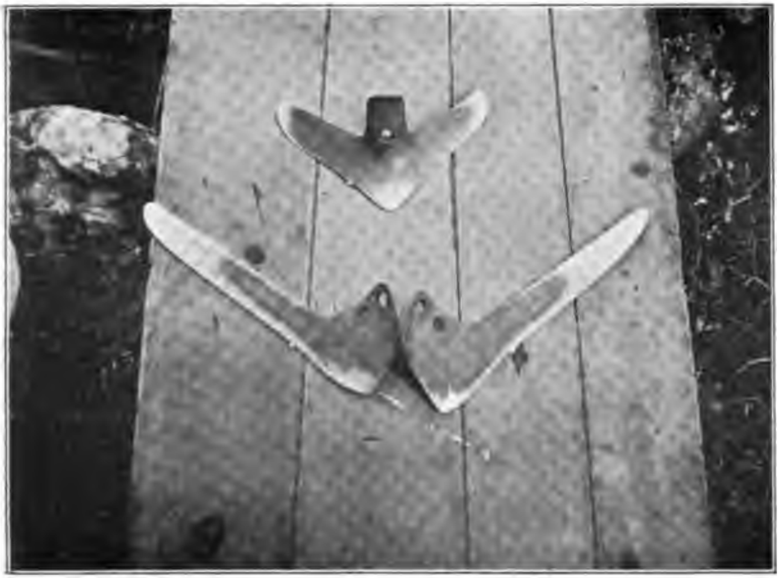

FIGURE 5. The potato hilling side and center hoes, which when turned backwards are such effective implements in weed killing. They are attached at the rear of the cultivator. (Figure 4 on opposite page.) (See text, page 425.)

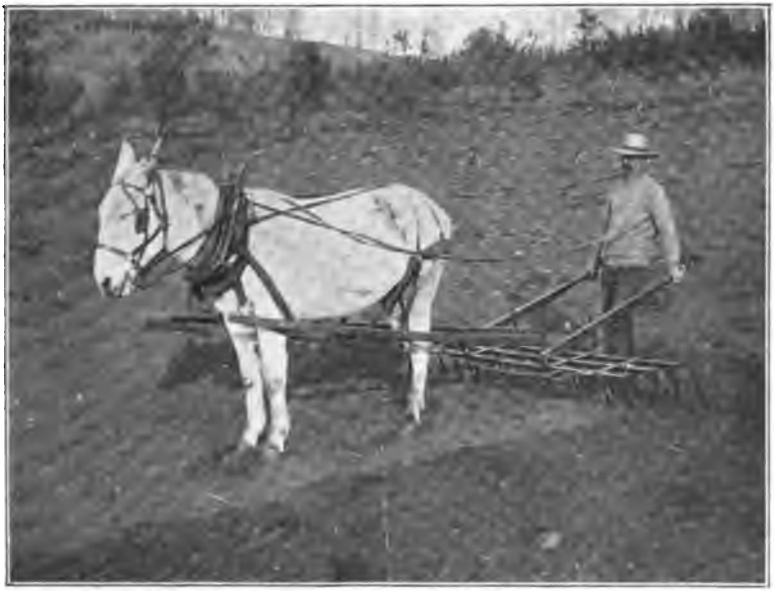

FIGURE 6. Running the weeder over the ridges the same day that the cultivation illustrated in figures 2 and 4 is carried out. (See text, page 425.)

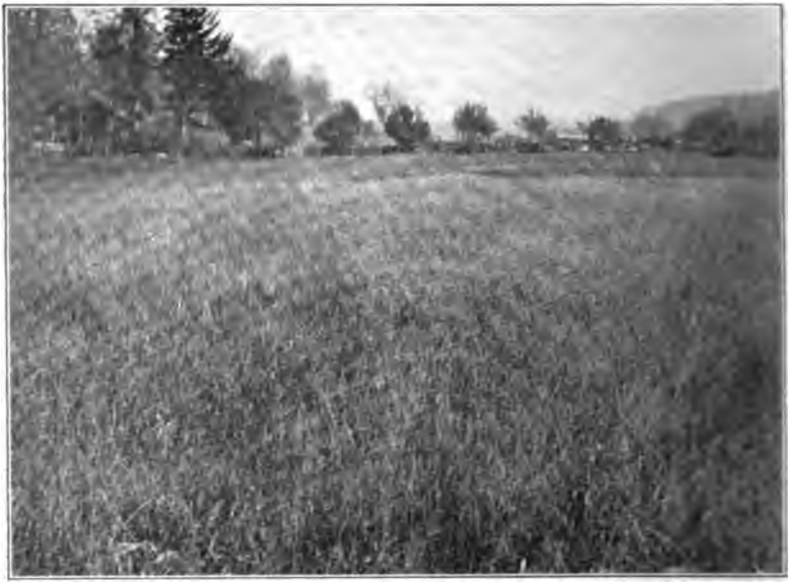

FIGURE 7. A typical witch grass corn field after the corn has been harvested. This field is located on soil similar to that on the Eaton farm. Compare with figure 8 below. (See text, page 425.)

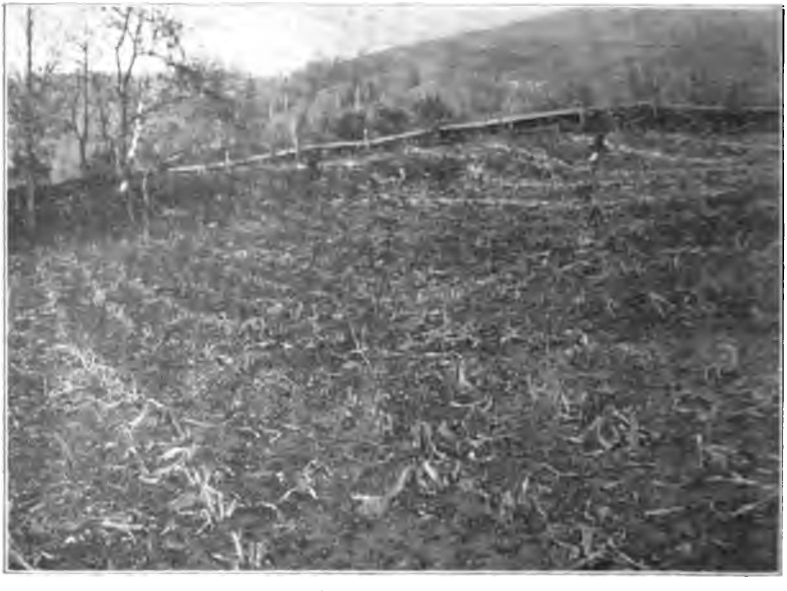

FIGURE 8. A representative portion of the 1909 corn ground on the Eaton farm. A few years ago this was nearly as badly infested with witch grass as is that shown in figure 7 above. See also figures 17 and 18 showing witch grass infested and witch grass cleared potato fields. (See text, page 422.)

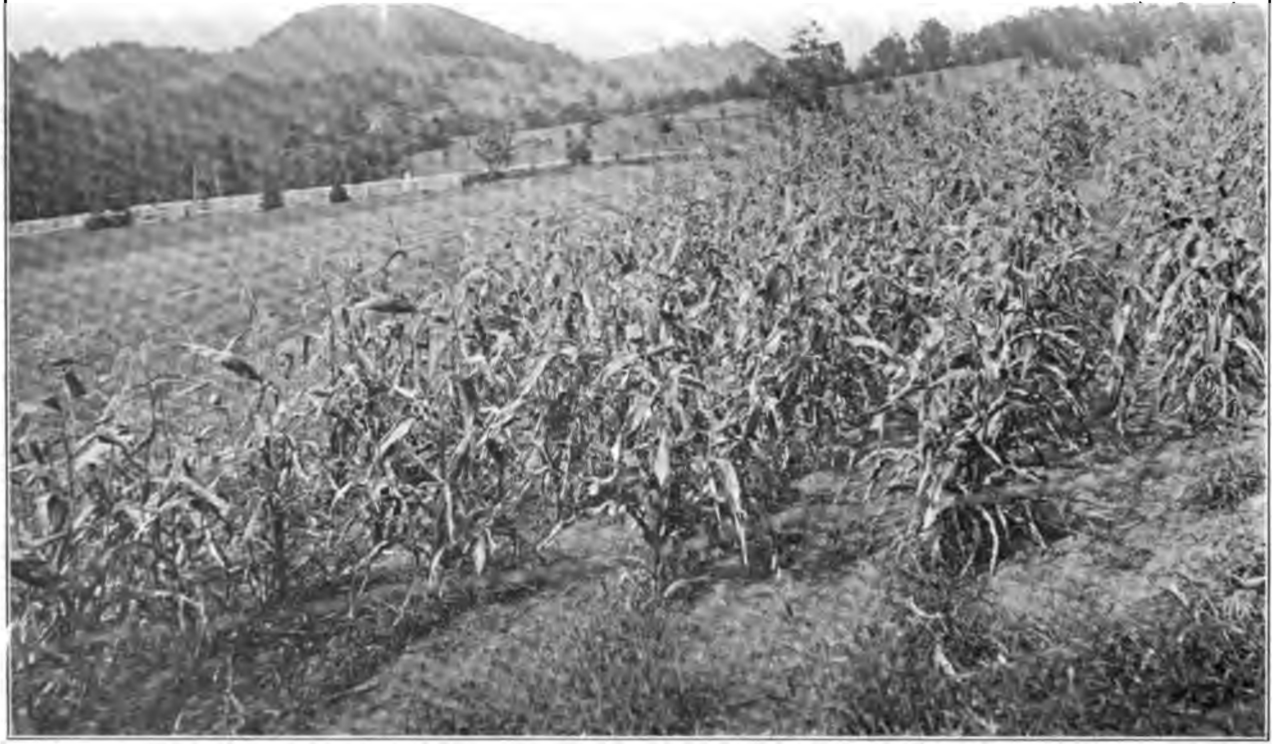

FIGURE 9. Plot 1 on upland stony loam. Witch grass almost absolutely eradicated at a cost per acre, over and above the owner's treatment of the residue of the field, of $5.40. Two and a quarter more tons of corn per acre grown than on a similar area of the untreated residue of the piece. Compare with untreated portions, figures 11 and 12. Note contrast where treated and untreated areas join (figure 10), also condition after harvest (figure 13). (See text, pages 433-436.)

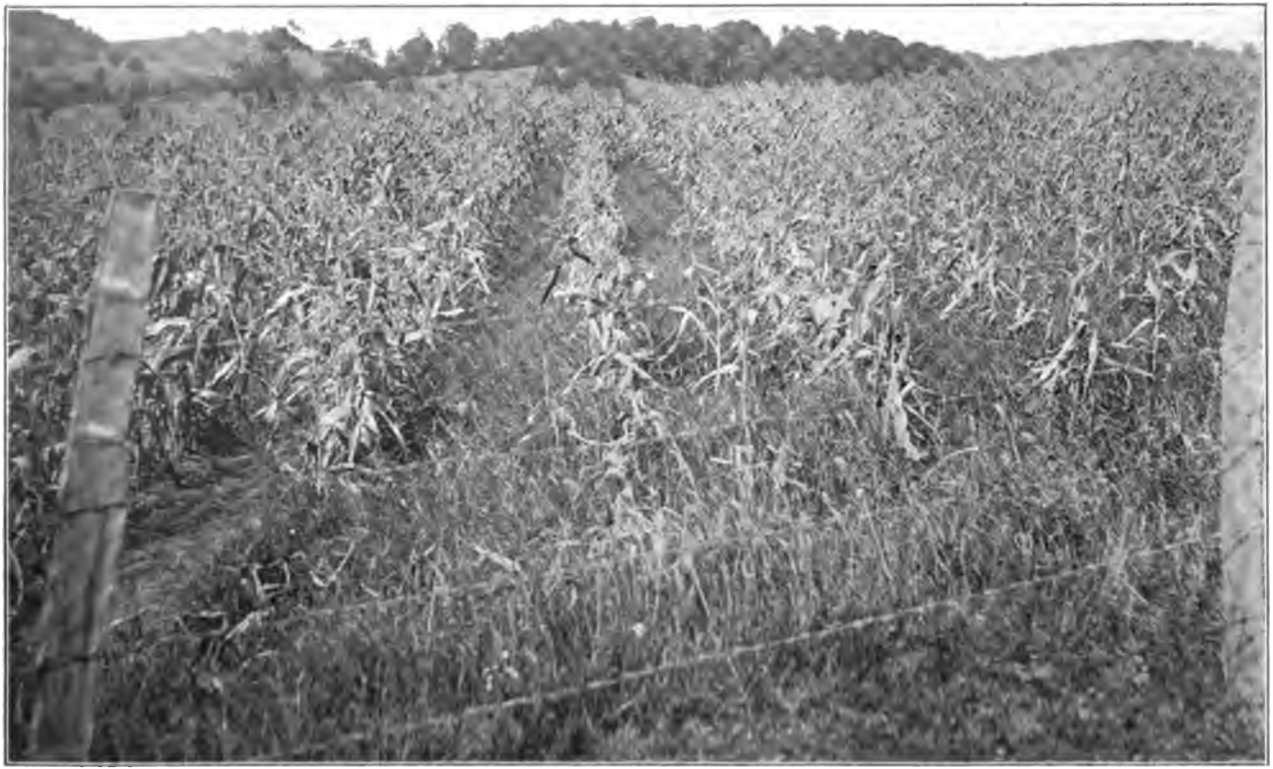

FIGURE 10. Plot 2, on upland stony loam. "Witch grass enough to make a ton of hay to the acre." Less than half as much green corn and ears grown as on the adjoining treated area. See figure 11, showing contrast between the two; also figure 13 showing condition after harvest; and figure 19 showing the ears grown on the treated and untreated pieces. (See text, pages 133-136.)

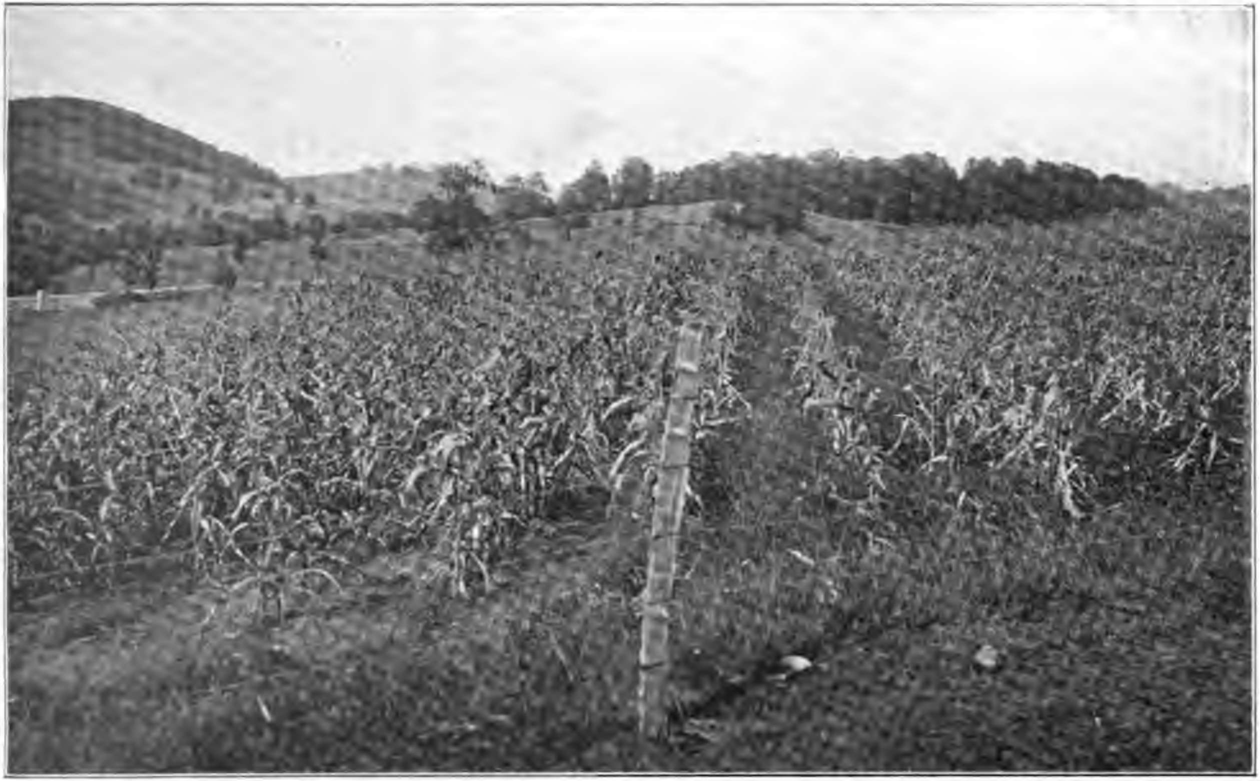

Figure 11. The contrast in growth between the treated and untreated areas, plots 1 and 2. The untreated area was frost bitten; that where the witch grass had been killed was vigorous and green. (See text, pages 433-436.)

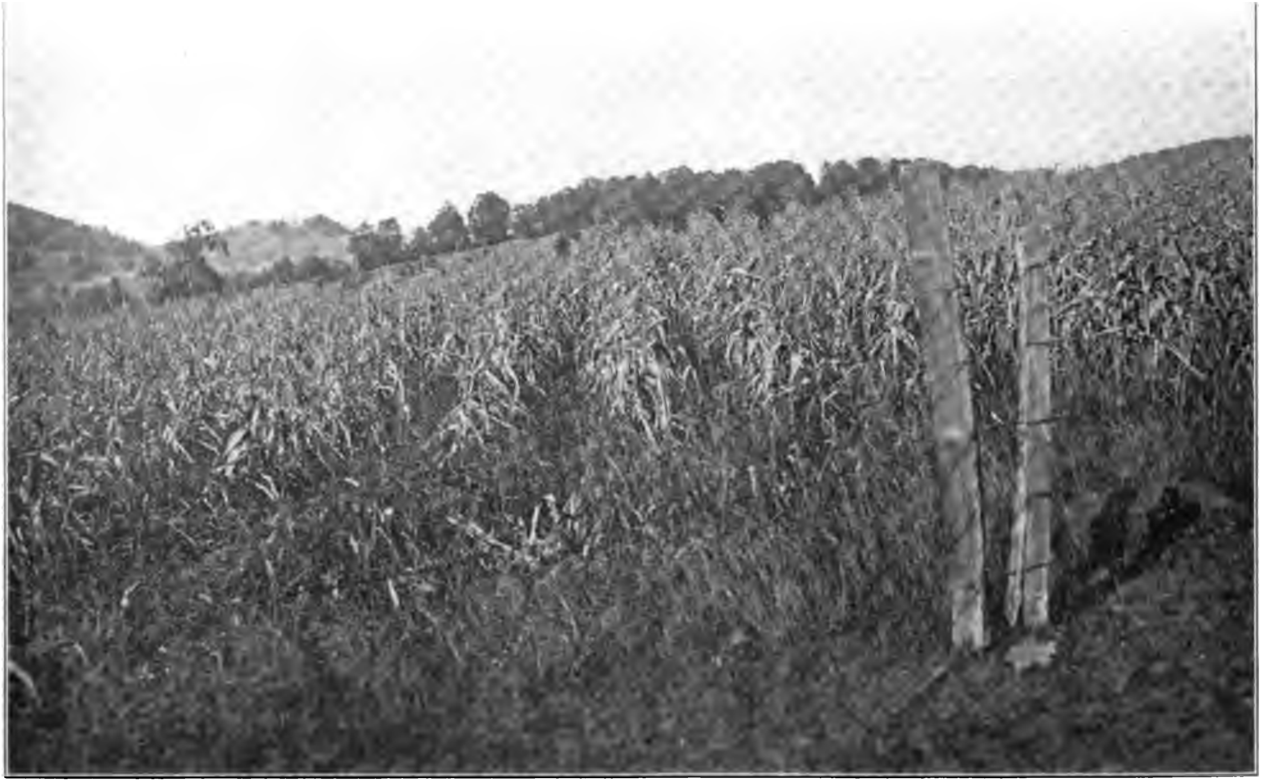

FIGURE 12. Plot 3 on upland stony loam. "Witch grass enough to make a ton of hay to the acre." Fully an average of the entire area of the piece which was not treated, yet growing only two-thirds as much corn as was grown on that portion which was specially tilled. Compare with figures 9 and 11; see also figure 19 showing ear corn grown on the two portions of the field. (See text, pages 433-436.)

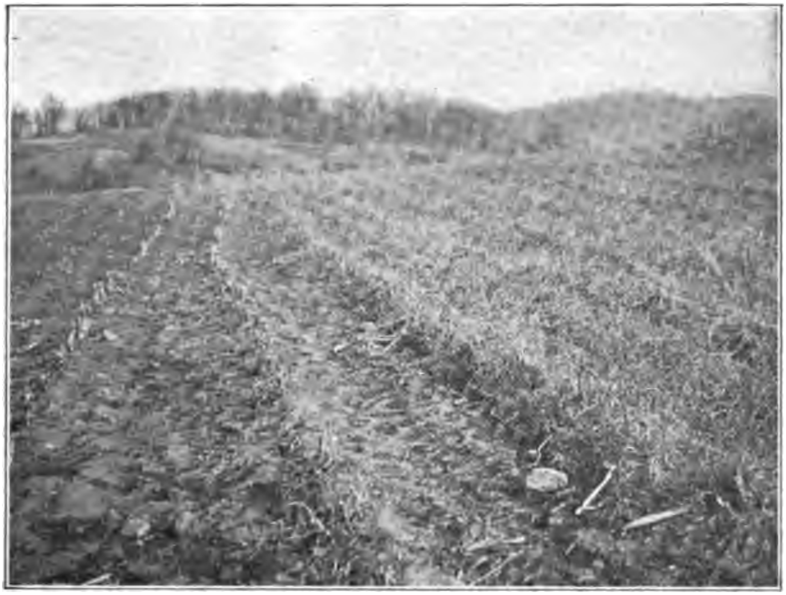

FIGURE 13. Plots 1 and 2 on upland stony loam. After the crop had been harvested. Compare with figures 9 and 10. The witch grass had been trampled before the photograph was taken. Immediately after harvest plot 2 looked like the field illustrated in figure 7, which see. (See text, pages 433-436.)

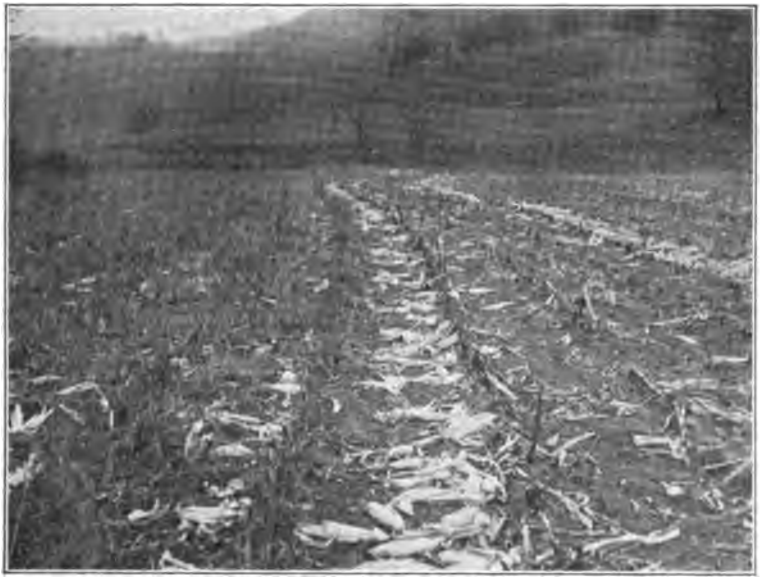

FIGURE 14. Plots 4 and 5 on the river meadow sandy loam, after harvest. The taller weeds which grew on the untreated area were cut, harvested, and bound with the corn. On the treated area witch grass was almost entirely eradicated. The cost over and above that of the treatment of the rest of the field by the owner was $9 per acre. One and five-eighths tons of green corn per acre was grown in excess on the treated as compared with the untreated area. (See text, pages 436-439.)

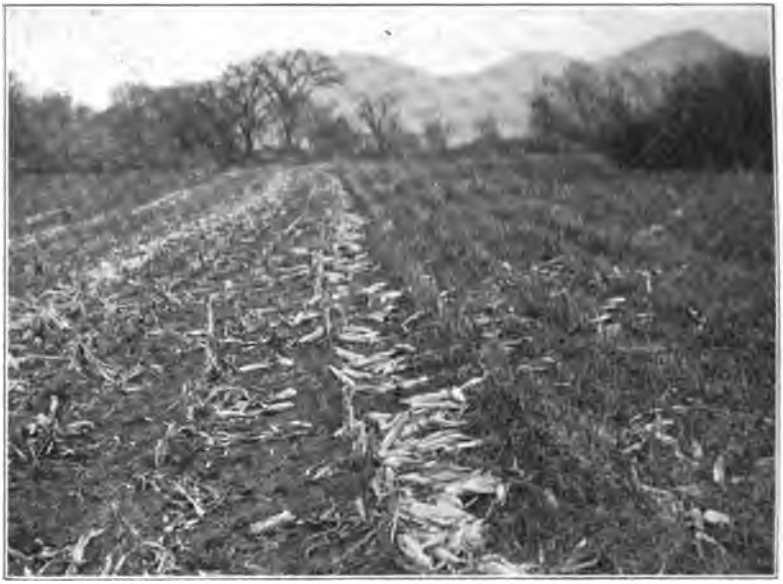

FIGURE 15. Plots 4 and 5 on river meadow sandy loam. The taller weeds growing on the untreated area were cut with the corn harvester and bound with the corn. On the treated area witch grass was almost entirely eradicated. The cost over and above that of the treatment of the rest of the field by the owner was $9 per acre. One and five-eighths tons of green corn per acre was grown in excess on the treated as compared with the untreated area. (See text, pages 436-439.)

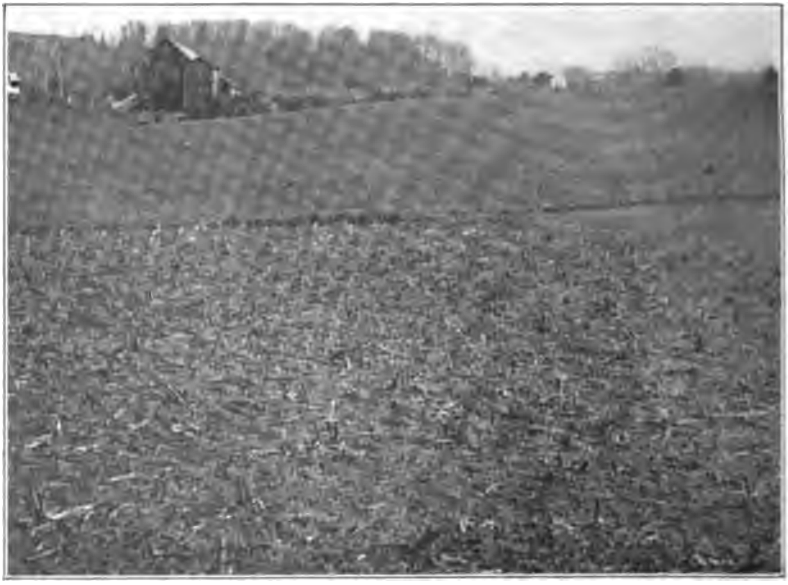

FIGURE 16. Plot 6 on the clay loam, after harvest. Some witch grass was left on the worst infested plots. The corn crop was decidedly increased on the treated area as compared with the untreated area. (See text, pages 439-441.)

I. ON STONY UPLAND LOAM

The plot selected for treatment consisted of eight rows planted 3½ feet apart, on an average 451 feet long, the plot containing between one-fourth and one-third of an acre (figure 9). It was located on the lower side, topographically, of a two-acre piece. This choice was based on the statement of the owner that no worse witch grass could be found on the farm than grew where these eight rows were planted. Both plowing and harrowing were very shallow, the former barely five inches. This slight depth of loose soil is an important factor in the comparatively small size of the crop and the relatively heavy cost of the special treatment. The entire piece received thirty loads of manure and 300 pounds of commercial fertilizer per acre.

The two rows adjoining the eight rows, omitting the one which was tilled on one side and not on the other, were selected for comparison and called plot 2 (figures 10, 11, 13). At the time the samples were taken the contrast between the two plots was so striking, that the owner was led to suggest that possibly the underlying ledge was nearer the surface under plot 2 than under plot 1, and that this might in part account for the decided difference. He thought that a fairer comparison might be made by selecting rows from another portion of the field. While no differences in soil conditions as between plots 1 and 2 sufficient to cause appreciable variation in the crop were apparent at the surface, in order to avoid any possibility of error from this source, and to give the untreated area every possible advantage, plot 3 was selected (figure 12) from that portion of the field suggested by the owner, on which grew a larger, but doubtless no more than average, crop.

The history of this piece of corn so far as it relates to the matter in hand is exhibited on page 434. The prices for the various pieces of work are listed on the acre basis. Thus, when the statement is made that ridging in June cost 75 cents, it means that had an acre been thus ridged it would have cost 75 cents for labor, at the rate at which the small area was worked.

Plot 1 (treated). Planted, May 31; ridged, June 9, 75 cents; cultivated twice in row, June 12, $1; leveled with weeder, June 12, 25 cents; cultivated twice in row, June 21, $1; weeded, June 21, 25 cents; cultivated twice in row, June 27, $1; cultivated twice in row, July 10, $1; hoed by hand, mid-July, $5.25; cultivated twice in row, July 19, $1. Total cost of treatment per acre, $11.50.

Plots 2 and 3 as well as the residue of the field (untreated). Planted May 31; harrowed once after planting, 35 cents; cultivated twice in row, $2; hoed by hand early, $3; cultivated, two horse cultivator, 75 cents. Total cost per acre, $6.10. This treatment represents the owner's statement as to his handling of the crop, the prices for man and team labor being as indicated in the footnote on page 428, and the same as employed in calculating the cost of the special treatment.

As to the killing of the witch grass. Plot 1 (treated). A very little witch grass was seen in the corn hills and none elsewhere. All other weed growth seemed to be killed (figures 9, 10, 13).

Plots 2 and 3 as well as the remainder of the field (untreated). This carried enough witch grass to make a ton of hay per acre (figures 10-13). At the time the photograph was taken, after the corn crop had been removed, cattle had been pastured on this lot for several days, so that the grass was trampled down, to such an extent that the photograph from which figure 13 was made failed to do the situation justice. For this reason a photograph was taken of a neighboring field, which at that time was in the same condition as were plots 2 and 3 at the time when the corn was harvested. This view is exhibited in figure 7.

As to the corn crop. The acre yields, computed from the carefully determined areas, plant counts, and sample counts and weights, were as shown on the opposite page.

Plot number and history.	Green fodder lbs.	Green ears lbs.	Green stover lbs.
1 (treated),	12,860	4,150	8,710
2 (untreated, adjacent),	5,780	1,780	4,000
3 (untreated), average,	8,420	2,990	5,430
1 (treated) exceeded 3 (untreated), pounds, .	+4,440	+1,160	+3,280
1 (treated) exceeded 3 (untreated), percentages,	+ 53%	+ 34%	+ 60%

The analytical results afforded the following comparisons. Plots 1 and 3 only are compared in order to do the untreated area no injustice. If the results from plot 2 were used, the showing for the treatment would obviously be very much better.

POUNDS OF CRUDE NUTRIENTS PER ACRE

Plot number	Green corn	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen free extract matter	Ether extract
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1 (treated),	12,860	3,336	145	305	612	2,185	89
3 (untreated),	8,420	2,594	100	184	511	1,742	57
1 (treated) exceeds 3 (untreated), pounds,	+4,440	+742	+ 45	+121	+101	+443	+32
1 (treated) exceeds 3 (untreated), percentages,	+53%	+29%	+45%	+66%	+20%	+25%	+56%

There grew on the treated plot, calculated to the acre basis, as compared with what was deemed to be the average growth on the untreated area; two and a quarter tons more green corn, over one-half ton of which consisted of green ears, an increase of 53 percent in the total crop and 30 percent in the green ear corn. There was an increase of 29 percent dry matter, and presumably in digestible food nutrients as a whole, of 66 percent protein, and of 25 percent carbohydrates and fat. One would have had to have bought 300 pounds of cottonseed meal costing about $5.25, or 800 pounds of bran costing over $10, to have placed on the barn floor the equivalent of the extra protein grown on the treated acre over and above that produced on the untreated acre.

The extra cost involved in this special cultivation was $5.40 ($11.50—$6.10). In short, for an added expenditure for labor of $5.40, two and a quarter tons of green fodder corn were raised over and above that grown on the untreated piece; and in addition the witch grass was almost entirely annihilated. Two dollars and forty cents is not an exorbitant price for a ton of standing green corn, fairly well eared (32 pounds in 100). It does not seem too much to claim that in this particular case the extra crop paid for the extra labor, and that the witch grass was nearly all killed out for nothing. Another year's effort, and a far less laborious one, will finish the small amounts left in the corn hills.

II. ON RIVER BOTTOM SANDY LOAM

The plot selected for treatment consisted of eight rows, averaging 843 feet long, planted three feet apart, and containing nearly half an acre. This long tract was located on a river meadow of even topography and fairly uniform soil, save for the narrow sandy strip mentioned on page 432. The second and third rows on either side of the treated plot, four in all, were chosen for comparison and called plot 5 (figures 15, 16). The entire piece was fertilized by the owner with 18 loads of manure and 200 pounds of commercial fertilizer per acre. The corn was up nearly two inches before the rows were ridged. Many of the sprouts were broken off in harrowing, and sometimes several hills were destroyed. This fact accounts in part for the somewhat thin stand of corn on the plot and the consequent small yield. Roughly about one plant in five seems to have been killed by the special tillage. At the time the samples were taken, in late September, the crop was immature. Had they been taken two weeks later, a better showing would have been made.

The history of this piece of corn, so far as it relates to the matter in hand, is as follows, the prices being made on the acre basis. The conduct of the tillage operations on plot 5 was dictated by and they were carried out by the owner.

Plot 4 (treated). Planted, May 31; ridged, June 9, 75 cents; cultivated once in row, June 12, 85 cents; cultivated twice in row, June 21, $1; weeded, June 21, 25 cents; cultivated twice in row, June 26, $1; cultivated twice in row, July 1, $1; cultivated twice in row, July 10, $1; cultivated twice in row, July 19, $1; hand hoed, late July, $3; cultivated twice in row, July 30, $1. Total cost of special treatment per acre, $10.85.

Plot 5, as well as the residue of the piece (untreated). Handled by the owner in the customary manner. Planted, May 31; harrowed once, 35 cents; cultivated three times, $1.50. Total cost per acre, $1.85.

As to the killing of the witch grass. Plot 5 (treated). This entire area was practically cleared of witch grass and of all other weeds, excepting horse tail. A very few scattering sprouts of witch grass could be seen in the corn hills, but none anywhere else. (Figures 14, 15.)

Plot 6 (untreated). There was witch grass enough on the dryer portion of the field to make a ton of hay to the acre. On its moister portions, however, there was much less witch grass, but pigweeds, milkweeds and six foot barngrass abounded. The corn on this piece was cut with a harvester, so that the tall weeds on the untreated areas were bound in with the corn and do not shown in the photograph, which shows the condition after the crop was out. (Figures 14, 15.)

As to the corn crop. The acre yields, computed from the carefully computed areas, plant counts, sample counts and weights, were as follows:

Plot number and history.	Green fodder lbs.	Green ears lbs.	Green stover lbs.
4 (treated),	22,020	5,680	16,340
5 (untreated),	18,770	4,570	14,200
4 (treated) exceeded 5 (untreated), pounds,	+3,250	+1,110	+2,140
4 (treated) exceeded 5 (untreated), percentages,	+18%	+24%	+15%

The analytical results afford the following comparisons:

POUNDS OF CRUDE NUTRIENTS PER ACRE

Plot number	Green corn	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen free extract matter	Ether extract
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
4 (treated),	22,020	5,089	203	410	993	3,335	148
5 (untreated),	18,770	4,402	169	314	894	2,931	94
4 (treated) exceeds 5 (untreated), pounds,	+3,250	+ 689	+ 34	+ 96	+ 99	+ 404	+54
4 (treated) exceeds 5 (untreated), percentages,	+18%	+16%	+20%	+30%	+11%	+ 14%	+58%

There grew on the treated plot calculated to the acre basis as compared with the untreated areas; one and five-eights tons more green corn, over one-half ton of which consisted of green ears. There was an increase of 18 percent in the crop and 24 percent in the green ear corn. There was an increase of 16 percent of dry matter—and presumably in the contents of digestible nutrients—, of 30 percent of crude protein, and of 14 percent of carbohydrates and fat. One would have had to have bought 250 pounds of cottonseed meal costing nearly $4.50, or 600 pounds of bran costing about twice as much, to have placed on the barn floor the equivalent of the extra protein grown on the treated acre as compared with the untreated acre.

The extra cost of the special treatment was $9 ($10.85—$1.85). For an expenditure of $9 in labor, one and five-eighths tons of green fodder corn were raised over and above that grown on the untreated area; and, in addition, the witch grass was almost entirely killed out. This is at the rate of $5.50 a ton. Five dollars and a half is a high price to pay for standing green corn; but it may be claimed with safety that the extra crop paid at least one-half the expense of the slaughter of its enemy, reducing the cost of the combat to a low figure. And, moreover, there was so little witch grass left, not to speak of the other weeds killed, which were in great quantity, that next year the fight needed to kill out the remainder will be relatively a pastime.

III. ON CLAY LOAM

The plot selected for treatment consisted of a dozen short rows, planted three feet apart and a little over forty feet long, on one side of a large field (figure 17). It comprised barely one-twenty-fifth of an acre, being hardly larger than a small sized garden plot. These rows were full of witch grass, while those adjoining, selected for purposes of comparison, were less thoroughly infested. The entire piece, a very lumpy clay loam, was fertilized with 15 loads of manure and approximately 250 pounds of wood ashes to the acre.

The history of this piece, so far as it relates to the matter in hand, is as follows, the price for work being calculated on the acre basis, the untreated rows being handled by the owner as he saw fit.

Plot 6 (treated). Planted, May 28; ridged, June 2, 75 cents; cultivated once in the row, June 7, 50 cents; weeded, June 7, 25 cents; cultivated once in row, June 12, 50 cents; weeded, June 12, 25 cents; cultivated twice in row, June 21, $1; weeded, June 21, 25 cents; cultivated twice in row, July 16, $1; hoed by hand, mid-July, $3. Total cost of special treatment per acre, $7.50.

Plot 7, as well as the residue of the field handled by the owner in the customary manner (untreated). Planted, May 28; weeded, 25 cents; cultivated twice in row, $1; hoed with a horse hoe, 75 cents; kale pulled by hand, 25 cents. Total cost per acre, $2.25.

As to the killing of the witch grass. Plot 6 (treated). Some witch grass remained in the worst spots, but there were no other weeds left (figure 16).

Plot 7 and the residue of the field (untreated). A great many weeds flourished, especially barngrass and Roman wormwood. There was not much witch grass on this field, outside of the particular place chosen.

As to the corn crop. The acre yields computed from carefully determined areas, plant counts, sample counts and weights were:

Plot number and history.	Green fodder lbs.	Green ears lbs.	Green stover lbs.
6 (treated),	29,150	7,130	22,020
7 (untreated),	19,540	5,870	13,660
6 (treated) exceeds 7 (untreated), pounds,	+ 9,610	+1,260	+ 8,360
6 (treated) exceeds 7 (untreated), percentages,	+49%	+21%	+ 62%

The analytical results afford the following comparisons:

POUNDS OF CRUDE NUTRIENTS PER ACRE

Plot number	Green corn	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen free extract matter	Ether extract
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6 (treated),	29,150	5,700	236	452	1,178	3,712	122
7 (untreated),	19,540	3,944	150	307	832	2,555	100
6 (treated) exceeds 7 (untreated), pounds,	+9,610	+1,756	+ 86	+145	+346	+1,157	+22
6 (treated) exceeds 7 (untreated), percentages,	+49%	+45%	+57%	+47%	+42%	+ 45%	+22%

The plots on the clay loam were necessarily differently shaped than were the others and were made up of several small rows. As already remarked, the worst—almost the only—witch grass was located on the spot chosen for plot 6; and as witch

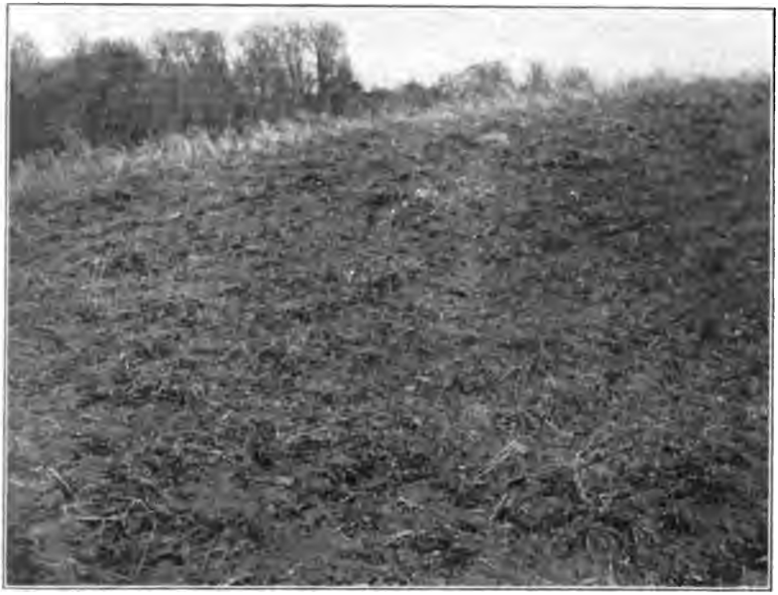

FIGURE 17. A witch grass infested potato field on which 800 pounds of commercial fertilizer had been applied in the spring of 1909. Yield, 70 bushels per acre. This piece possesses the same general soil characteristics and was in the same general condition as that on the Eaton farm prior to the inception of the special tillage operations. Compare with figure 18 below.

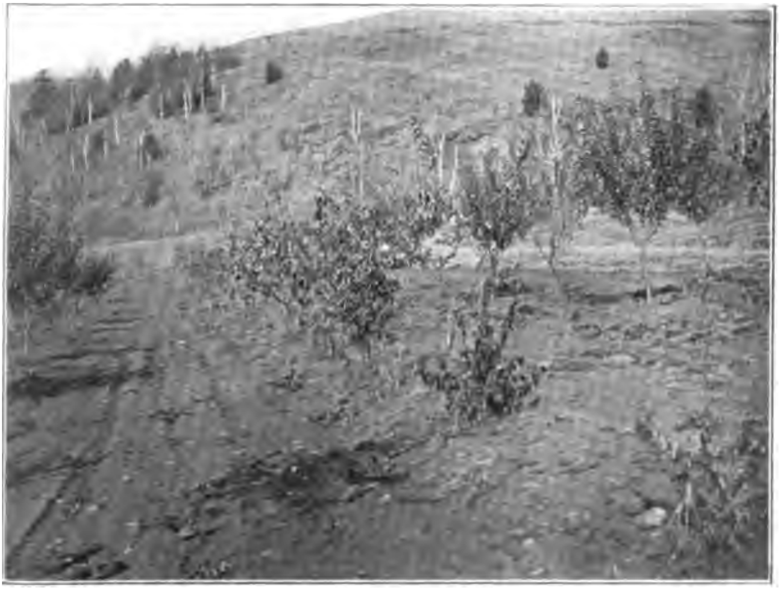

FIGURE 18. Potato field on the Eaton farm. In 1905 this field was as badly infested with witch grass as that pictured in figure 17 (above). The witch grass has been eradicated by the method outlined in this bulletin on pages 423-429. No commercial fertilizer was applied in the spring of 1909, nor has any been used for ten years. Yield in fall of 1909, 250 bushels per acre, making no allowance for waste land and tree areas. Compare with figure 17 above.

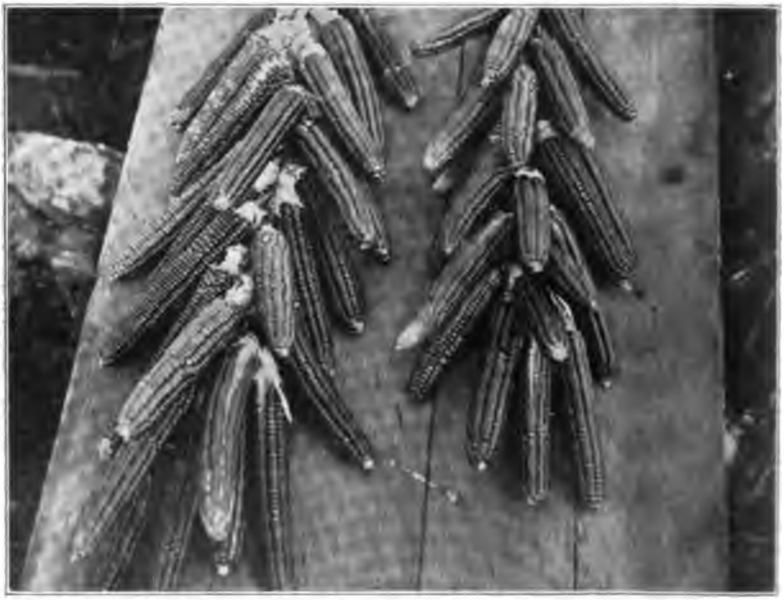

FIGURE 19. Two traces of corn consisting of 24 ears each. The left hand one from plot 1, a quarter of an acre in area; the right hand one from the residue of the piece, one and three-quarters acres in area. The left hand trace could have been duplicated indefinitely from the cultivated quarter acre. The right hand one represents the best found, after careful search, on the one and three-quarter acres of untreated area. It would have been difficult, perhaps impossible, to have duplicated this trace save by hours of search. On all the soils, but notably on the upland stony loam, the ears on the treated area were better filled out and heavier than those grown on the untreated area. They were likewise richer in protein. (See text, pages 443-444.)

grass killing was the prime object of the experiment, the plot was naturally placed there, and its size and shape determined by the local conditions. For reasons unnecessary to discuss, this plot received less attention than did the others; yet the results were pronounced. A most careful scrutiny of all the data leads to the conclusion that no error exists therein. Furthermore, it was noted at the time of harvest that the stalks of the corn on the treated area were decidedly larger than those on the untreated area; and, finally, this field as a whole was none too well cared for. Although the result is overwhelmingly in favor of the special tillage treatment, no stress is laid upon the great gains obtained. These are four and three-quarters tons of green fodder to the acre as a return for $5.25 of extra work in carrying out the special treatment. This is equivalent to a ton of standing fodder corn at $1.10, with the witch grass killing thrown in for good measure. The gain was mostly in stover, but one-half ton more green ears to the acre being grown. The crop was immature at the time of harvest.

IV. ON VERY SANDY SOIL

A field of corn was chosen for this trial on which but little witch grass grew, save on a knoll of almost clear sand which stretched along the length of the field. The plot selected for treatment ran along this sandy strip, and consisted of 10 rows planted 3 feet apart, averaging 270 feet in length, the area approximating one-sixth of an acre. It contained a great deal of witch grass in spots, although by no means as badly infested as were the fields on which plots 1 and 4 were located. There also grew considerable Mexican drop seed grass along these rows. The control plot (untreated), upon which grew little or no witch grass, consisted of two adjacent rows located to one side of the chosen ten. The entire piece was fertilized with 450 pounds of commercial fertilizer to the acre. The residue of the piece was not quite as sandy as was the knoll selected.

The history of the piece, so far as it relates to the matter in hand, is as follows, prices being made on the acre basis and the handling of the piece, outside of the special plot, dictated by and carried out by the owner:

Plot 8 (treated). Planted, May 21; ridged, May 31, 75 cents; cultivated once in row, June 3, 75 cents; cultivated twice in row, June 12, $1; weeded, June 12, 25 cents; cultivated twice in row, June 21, $1; cultivated twice in row, July 16, $1; hand hoed, mid-July, $2.50. Total expense of special treatment per acre, $7.25.

Plot 9, as well as the residue of the field, (untreated). Planted, June 21; weeded, 25 cents; cultivated three times, $1.50. Total expense per acre, $1.75.

As to the killing of the witch grass. The experimental plot was practically cleared of all weeds, including witch grass, save some little horse tail. On the untreated plots, on which no witch grass grew, Roman wormwood and Mexican drop seed grass grew abundantly. Comparatively few other weeds occurred.

As to the corn crop. The acre yields, computed from the carefully determined areas, plant counts, and sample counts and weights, were as follows:

Plot number and history.	Green fodder lbs.	Green ears lbs.	Green stover lbs.
8 (treated),	21,400	6,000	15,400
9 (untreated),	19,780	5,860	13,920
8 (treated) exceeds 9 (untreated), pounds,	1,620	140	1,480
8 (treated) exceeds 9 (untreated), percentages,	+8%	+2%	+11%

The analytical results afford the following comparisons:

POUNDS OF CRUDE NUTRIENTS PER ACRE

Plot number	Green corn	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen free extract matter	Ether extract
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8 (treated),	21,400	5,382	216	360	1,043	3,632	131
9 (untreated),	19,780	5,365	200	322	1,115	3,601	127
8 (treated) exceeds 9 (untreated), pounds,	+1,620	+ 17	+ 16	+38	—72	+ 31	+4
8 (treated) exceeds 9 (untreated), percentages,	+ 8%	+11%	+8%	+12%	—7%	+9%	+3%

The outcome in this case is nil; and that is perhaps just what might have been expected, for the control plot carried no witch grass on it, and, hence it did nearly as well as that which was freed therefrom. On a soil so sandy as was this knoll, no process of cultivation is likely to do wonders in the matter of the conservation of moisture. The gain for the expenditure in labor in carrying out the special treatment, over and above that spent by the owner in cultivating his crop, amounting to $5.50 ($7.25—$1.75), is mostly found in weed eradication, only three-quarters of a ton larger crop being obtained.

THE EFFECT UPON THE EARS OF CORN

The mature ears from the treated pieces were invariably better filled out than were those grown on the untreated pieces. The two traces of seed corn which are shown in figure 18 were taken respectively from plot 1 and from the entire residue of the two-acre piece in which plot 1 was located. Each of these traces contained 24 ears. Those from plot 1 were taken at random. The lot could have been duplicated with ease fifty times over from the one-quarter acre plot. On the contrary, the 24 ears representing the one and three-quarters acres outside of the treated area were gathered as being on the whole representative of the best on the untreated piece. It would have been difficult to have duplicated this lot many times from the untreated area. While the difference was more marked perhaps on this field than on either of the other four, it was very noticeable that in general the ears on the untreated areas were not as well filled out at the tip as those grown on the treated areas, being pointed and often without kernels. A few such are shown in the trace of best ears representing the untreated area pictured in figure 18. On the other hand, the ears grown upon the plots receiving this special treatment were almost invariably well filled out at the tip and rounded.

THE EFFECT UPON THE PROTEIN CONTENT OF THE CROP

The chemist calls the attention of the writer to the marked differences in the protein contents of the green ears from the treated and untreated plots, and to the less marked, but still considerable, differences in the protein content of the green stover.

PROTEIN CONTENT OF EARS AND OF STOVER

	Treated	Untreated	Treated	Untreated
	Ears		Stover	
	%	%	%	%
Plots 1, 2, 3,	3.81	3,21	1.68	1.50
Plots 4, 5,	3.74	3.42	1.21	1.10
Plots 6, 7,	2.83	2.80	1.15	1.04
Plots 8, 9,	3.62	3.31	0.94	0.91

More and larger ears, better filled out and more proteinous, as well as more and better stover, seem to result from the employment of this process. In brief, a larger crop of a higher feeding value was grown where the special tillage operations were carried out; and, in addition the witch grass was killed.

AFTER EFFECTS

Doubtless the effect of eradication of the weed will be shown in the size of the succeeding crops. One of the fields used the past year will be sown to oats in the spring and seeded with timothy and clover. That the crop on the cleared area will exceed that on the witch grass sod land is a fairly safe prediction; also that the succeeding hay crop will be benefited by the treatment.

Stress should be laid on the point that the immediate gains shown this year are but partial indications of the total benefit to be derived; and that a literal interpretation of the figures comparing cost of the treatment and the increased corn crop is unwarranted. It would be like comparing the cost of railroad construction with the first year's earnings of the road. The monies spent in the construction of a railroad constitute a permanent investment; and so is the expense entailed by the conduct of a procedure such as is outlined in this bulletin.

THE FROSTED AND UNFROSTED CORN

The corn on the upland stony loam piece was badly frosted before harvest (late September), save that located on plot 1. Every hill on the treated quarter acre was green and vigorous, save for such natural ripening of the lower leaves as commonly occurs on mature corn. It carried 26 percent of dry matter and was practically ready for the silo. All the rest of the field was whitened by frost. The contrast was most marked and the line of demarcation was exact along the line of the plot. Indeed, the row one side of which was tilled whereas the other side was not, was slightly frosted. It was, in other words, in an intermediate state between its frosted and unfrosted neighbors. The reason for this peculiar result is not understood with certainty, although the station botanist and assistant botanist hazard the conjecture that the effect was the result of a combination of causes. The most important was probably the holding of air by the larger growth of corn in the treated plot. In other words, the circulation of the atmosphere was so restricted, that the temperature remained more constant than was the case in those parts of the field which developed a less satisfactory growth. It is possible also that more vigorous metabolic activities in the treated plot resulted in the evolution and radiation of more heat, thus tending to keep off frost. It should be remembered, however, that the distribution of frost in fields is always somewhat problematical, and is often to be explained only by a study of the peculiar local air currents, which vary in different parts of the same field.

THE RATIONALE OF THE PROCEDURE

Why should this special soil tillage procedure, when adequately conducted, kill witch grass so effectually as almost entirely to destroy it the first season and entirely so the second? And why should the corn crop as a result be increased?

The secret is probably found in the fact that this system of tillage prevents witch grass from making leaf. It is well known that the food of green plants is manufactured in their green parts, under the influence of the sunlight and the chlorophyll. If this process is interfered with for a sufficient length of time, any plant, no matter how hardy, must necessarily die from starvation. There is a certain quantity of stored food in the creeping root stocks of witch grass, but this is sufficient to keep the plant supplied for only a few weeks. By preventing the plant from replenishing this food supply, it is starved out.

It is easy to see why the corn crop ought to be increased as a result of this procedure. It is well understood that adequate tillage is an inciter of plant growth, and this special process is simply tillage and intertillage specially adapted to, and using appliances specially adapted for, the killing of weeds. Furthermore, it is well understood that a rank growth of weeds tends to consume plant food and moisture which otherwise would become available to a greater or less extent to the crop. The frequent cultivation called for by this method tends to increase the available plant food content of the soil; to offer larger feeding areas for plant roots to occupy; to lessen moisture evaporation; to promote soil aeration; and to bring about the manifold changes and betterments which it is well understood that adequate tillage affords.[1] It removes the competing crop, witch grass, so that the corn crop does not have to share therewith its food and moisture. Despite the fact that on two of the trial plots one corn plant in five may have been killed by this procedure, the remaining four-fifths, having a better chance, apparently more than made good the deficiency.

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[1] In this connection see article on "The Philosophy of Tillage" in bulletin 1 of the State Commissioner of Agriculture, and in the report of the same officer for 1909, for which apply to Hon. O. L. Martin, State Commissioner of Agriculture, Plainfield, Vt.

Witch grass can be killed and the cost of killing it met by increase of the crop.

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN NO. 150
MARCH, 1910

The Role of Anesthetics and other Agents in Plant Forcing.

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BULLETIN 150: THE ROLE OF ANESTHETICS AND OTHER AGENTS IN PLANT FORCING[1]

William Stuart

Since the autumn of 1903 the writer has been more or less interested in the use of anesthetics in plant forcing. The results of some of these studies have been previously presented in station publications, (14) and more recently were used in an address before the Massachusetts Horticultural Society. (15)

With the progress of investigation along this line both in Europe and America have come varying opinions concerning the exact effect produced in the plant by anesthesia, which have resulted in the employment of other agents as substitutes for anesthetics. This phase of the general subject has proved a most interesting one to the writer; and he ventures to express the hope that the results attained in the tests detailed herewith may prove suggestive to those engaged in similar lines of effort.

HISTORICAL REVIEW OF PLANT ANESTHESIA

The discovery by Bernard (3) in 1878 that plants, like animals, were rendered insensible when subjected to ether fumes, served to establish the close physiological relationship between the animal and vegetable kingdom; but it failed to give any indication of its after effect upon plants when in a state of rest at the time of treatment. For the latter discovery we are indebted to Johannsen (9) of the Royal Danish School of Copenhagen, Denmark. Johannsen in 1890 conceived the idea that ether or chloroform might be successfully employed to bridge over the resting period of plants. His first experiments were made with willows and bulbous plants, and such promising results were obtained as to justify their presentation before the Royal Academy of Sciences of Copenhagen in 1893. The publicity attendant upon the presentation of Johannsen's paper quickly aroused an interest upon the part of other European

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[1] The writer wishes to acknowledge his indebtedness to Messrs. C. S. Pomeroy, R. E. Vaughan and H. V. F. de Thestrup, former assistants, for much painstaking work in the conduct of the experiments.

investigators and it was not long before many were engaged in efforts to demonstrate the practical value of anesthetics in plant forcing. At the present time the employment of anesthetics has become so general among European plant forcers, particularly in Germany and France, that nursery firms now advertise anesthetized plants for sale.

Thus far comparatively little interest in the use of anesthetics has been shown by commercial growers in America. This, in the writer's opinion, is due to the fact that there is relatively little demand for early forced lilac blooms and for such other hard wooded plants as are forced with more or less difficulty during the early part of the season.

EFFECT OF ANESTHETICS UPON PLANTS

Little is known regarding the actual effect of anesthesia upon plants. For purposes of discussion, however, its effect may be considered under two heads.

(a) The physiological effect upon plants in active growth, or what might be termed the "immediate effect."

(b) The growth acceleration, or after effect, upon plants in a state of rest.

(a) PHYSIOLOGICAL EFFECT OF ANESTHETICS UPON PLANTS IN ACTIVE GROWTH

Bernard (3) found that the sensitive plant could be rendered insensible to external stimuli after about a half hour's exposure to ether fumes. It was observed, however, that the effect produced was not identical to that resulting from outward shock, nor to sleep effect. The pulvinus at the base of the leaf petiole did not respond in the same way as in the case of a mechanical shock. On the contrary, it appeared to be rendered incapable of such reaction. The leaves assumed a slightly drooping position and became quite rigid.

Dubois (5) found that when succulent plants, such as echeverias, were subjected to ether fumes in a tightly closed receptacle for a certain time, large drops of water, the result of epidermal transudation, formed on the surface of the leaves. Under similar conditions oranges were found to assume the appearance of frozen fruit, through loss of moisture. His deduction from these and other experiments was "that the inmost action of anesthetics in general very closely approaches that of cold, in that cold prevents inhibition, induces the separation of water from the protoplasm in the frozen tissues, withdrawing it, just as ether extracts haemoglobin from the blood corpuscles."

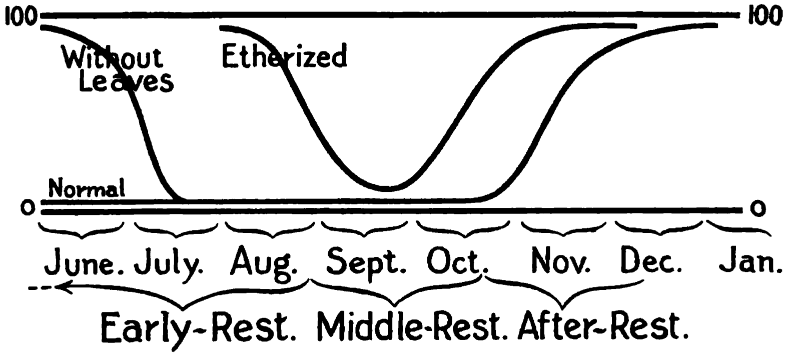
(b) GROWTH ACCELERATION, OR AFTER EFFECT OF ANESTHETICS, UPON PLANTS IN A STATE OF REST

As has been previously stated, Johannsen was the first to discover that anesthesia imparted a decided growth impulse to plants in a state of rest. Various explanations have been offered regarding the exact nature of this stimulus. Johannsen believed that the plant was thrown into such an intense and complete state of rest as materially to abridge its normal winter resting period. Maumené (11) suggests three theories, viz.:—"that it may be due to an acceleration of the order of growth; that it may be suspension of an arrest which has occurred in the natural growth; or that ether and chloroform may simply act as an excitant." Beltz (2) believed "that ether or chloroform caused an extension of the plant cells through exterior excitation." Drude (4), Ledien and Naumann advanced the theory that ether and chloroform checked some of the changes within the plant, while at the same time it increased respiration. Aymard (1) was of the opinion that anesthetics acted on vegetable tissues as dehydrating agents; and in support of this statement cited an experiment with lily-of-the-valley pips, in which he found that those subjected to the dehydrating agency of phosphoric anhydrid forced even more quickly than when treated with ether vapor. Howard (7) showed almost as good results from a five days' desiccation of the buds of woody branches as were obtained from etherization. More recent experiments by Molisch (12) have demonstrated that a 10-12 hour immersion of flowering branches, or rooted trees or shrubs of woody plants, in hot water, produced as much growth acceleration, particularly with lilacs, as is obtained by etherization. He also demonstrated that the effect of hot water is purely a local one by immersing one-half the shoots of a branch or tree in the warm water. In every instance when subjected to this treatment the immersed portion developed flowers and leaves very much in advance of the untreated portion.

In the light of the latter investigations it would appear that moisture extraction as well as the cessation or arrest of growth through anesthesia while doubtless contributory causes are not the only ones to which the observed facts may be ascribed.

REST PERIOD OF PLANTS

It is well known that all deciduous and herbaceous outdoor plants in northern latitudes exhibit certain well defined periods of rest, the intensity of which is not uniform for all plants. Johannsen has very aptly and suggestively divided this resting stage into three periods which he calls the "before rest," "mid-



Graphic chart illustrating the early, middle, and after rest periods as interpreted by Johannsen. The curves show the variation from the normal growth curve of the lilac produced by stripping the leaves from the plants and the use of ether. It will be noted that the period of most intense rest in this case is during the latter part of September.

dle rest" and "after rest" periods. In the before and after rest periods the plant is most easily incited into growth. During the middle rest period, however, the plant responds much less readily to external stimuli, such as heat, moisture and light. The accompanying chart (after Johannsen) illustrates the growth curve of plants passing through the dormant season. The deepest period of rest, as indicated by the ether curve, seems to be just a little prior to the center of the middle rest period. It will also be noted from the chart that in only a comparatively limited portion of this period does the plant fail to show marked growth acceleration from the use of ether.

MECHANICAL APPLICATION OF ANESTHETICS

While there is no one method of subjecting plants to the vapors of anesthetics which may be considered superior to all others, there are certain general rules the observance of which enables one to attain a greater degree of uniformity of result and a higher percentage of success.

Woody plants like lilacs, spireas, viburnums, etc., force much more satisfactorily if grown in pots the season in which they are to be forced. In other words, better results are secured from pot-grown plants than from those grown in the open ground; at least such has been the experience of the writer. This has also been found to be true in the case of paeonies and iris.

The balls of earth of the plants to be treated should be reasonably dry. Their removal from the pots for treatment is not a necessary procedure. The earlier practice of completely covering the balls of earth or the pots with dry sand is unnecessary. The writer has secured quite as good results without such protection. Dry sawdust may be used if desired.

The receptacle to be used for etherization purposes should be so constructed as to be essentially air tight when closed. Wooden, metal, or cement cases may be used. Those used by the writer are constructed of two thicknesses of matched lumber, with building paper between. The interior is thoroughly coated with paraffin, applied while hot. The door fits tightly and after closing, the crack is filled with melted paraffin; hence there is no possibility of vapor leakage. The anesthetic used is poured through an opening in the top of the case upon a sponge held in a dish suspended immediately beneath. The sponge facilitates the vaporization of the anesthetic. The process is completed with the closing of this intake.

EXPERIMENTAL EVIDENCE OF GROWTH ACCELERATION DUE TO ANESTHETICS

The experimental evidence now at hand regarding the relative increase in earliness of blooming period as a result of anesthesia shows that the time element varies inversely to the earliness or lateness of the forcing period. It has been clearly shown by carefully conducted experiments that anesthetics impart a more decided growth impulse in the early and after rest period than in either the central portion of, or toward the close of, the dormant season. On the average one may expect, in such plants as lilacs, that those which are etherized will come into bloom from 8-10 days earlier than will the untreated plants. This period of difference is frequently very greatly exceeded. Harris (6) claims to have secured a ten days' gain with lilac Charles X, and in addition the etherized plant produced about three times the usual number of flowers. It was also noticed that the foliage was much more abundant and of a deeper green.

Lewis (10) reports very satisfactory results from etherized narcissus, gains of from 2-21 days being secured. Howitt (8) found that etherized astilbe japonica came into bloom a month to five weeks earlier than did untreated plants.

EXPERIMENTAL INVESTIGATIONS

The studies upon which the following statements are based were begun in the fall of 1906. Three lines of investigation were undertaken.

(1) The determination of the desiccating influence of anesthetics upon plants.

(2) The comparison of the relative value of anesthetics and other agents in plant forcing.

(3) The determination of the optimum-dosage and period of treatment for various classes of plants. In all cases the statement of the dosage represents the amount of liquid used for each cubic foot of air space contained in the receptacle.

(1) ANESTHESIA DESICCATION

The material used for this study consisted of bulbous stock including dutch hyacinths, narcissus, tulips and lilies in variety, white romans, amaryllis, gladioli corms, and lily-of-the-valley pips. This class of plants was selected because of the relative ease with which moisture losses could be determined as compared with potted plants, or those with a mass of soil attached to their roots.

The bulbs and corms were subjected to the fumes of ether and chloroform in air tight cases for periods varying from 48 to 96 hours.

In the earlier experiments, December 14-18, '06, the untreated bulbs, when weighed at the end of 72 hours' exposure to the air of the room in which treatment was made, showed no loss of moisture; hence it was assumed that their moisture content was practically that of the air, and, therefore, they were not reweighed at the close of the 96 hour period of treatment. In later experiments, however, it was found that this assumption was unwarranted and that as a matter of fact the untreated bulbs did lose moisture.

In the first set of experiments, dutch hyacinth bulbs, exposed to ether fumes for 96 hours, were found to sustain an average moisture loss of 4.1 percent, while those exposed to chloroform lost 3.8 percent. During the same period narcissi bulbs showed a loss of 4.8 percent from ether and 5.7 percent from chloroform. Lily bulbs sustained a loss of 7.7 percent from ether and 9.4 percent from chloroform, a loss sufficient to give them a decidedly wilted appearance and to render them unfit for forcing. Etherized tulips lost 5.9 percent while those which were chloroformed lost 2.2 percent of moisture. White romans showed a moisture loss of 5.9 percent from ether and 2.8 percent from chloroform. The results from gladioli corms were so conflicting as to preclude their use. The average moisture loss from all etherized bulbs was 4.7 percent, while that from those which were chloroformed was 4.5 percent.

The moisture loss was also determined in a second series of experiments December 25-27, '06, where the untreated bulbs were kept under conditions as nearly similar as possible to those endured by the treated bulbs, so far as room temperature and confinement was concerned. Unfortunately the chemicals used in the treatment were not the same as in the first series, acetone and methyl alcohol being substituted for ether and chloroform. The moisture loss from bulbs subjected to acetone for 48 hours was 2.1 percent as against 1.6 percent from those which were alcoholized and 2.8 percent from untreated bulbs. A third treatment, of the same duration as the second made at a somewhat later date, January 6-8, '07, gave a moisture loss of 3.1 percent when acetone was used, and 3.2 percent when the bulbs were untreated.

The results secured from the second and third treatments just noted would seem to indicate that neither acetone nor alcohol possess the power of removing moisture from the bulbs, for in each instance the natural moisture loss exceeded that occurring in the treated bulbs. In view of these results it would seem unwise to assume that the moisture loss noted in the first treatment was wholly due to the dehydrating action of the ether or the chloroform. A portion of it was undoubtedly due to natural causes. There is no question, however, that the moisture content of plants exposed to ether fumes is appreciably diminished in prolonged treatments. This was especially noticeable in the case of the lily bulbs.

Owing to the conflicting nature of the data secured on the flowering period of the treated bulbs it is impossible to draw any references in regard to the possible effect of the withdrawal of water from the plant cells.

Experiments by Howard (7) in the desiccation of woody branches through exposure to air in a warm room for periods varying from one to several days would seem to indicate that a five day treatment by this method did produce a marked growth acceleration. In some instances this acceleration was almost as pronounced as that obtained from ether.

A consideration of the foregoing results leads to the following conclusions: That ether and chloroform extract moisture from the plant, and, that according to Howard, the removal of a certain amount of moisture from the plant tissues favors the development of flower and leaf bulbs. Desiccation may therefore be regarded as a contributory factor in the forcing of dormant plants.

(2) THE RELATIVE VALUE OF ANESTHETICS AND OTHER AGENTS AS GROWTH ACCELERATORS

In all earlier experiments in plant anesthesia, ether has been the agent most commonly employed. Chloroform has been used to some extent, but as a rule ether has proved the most satisfactory agent.

Materials used.—In the experiments undertaken by the writer and his assistants, as many anesthetic and non-anesthetic substances were tried as practicable, including ether, chloroform, ethyl iodide, ethyl bromide, ethyl chlorid, methyl chlorid, methyl alcohol, amyl alcohol, tetra-chlorid of carbon, and acetone; and in addition, the mechanical effects of vacuum and of frost were studied.

Plants used.—The classes of plants experimented with included viburnums, spireas, forsythias, philadelphus, weigelias, syringas, prunus, deutzias, loniceras, azaleas, roses, astilbe, paeonies, iris, dicentra, asparagus, rhubarb, and a considerable variety of bulbous plants. It was soon found that, in order to force hard wooded plants with anything like satisfactory results, pot-grown plants had to be used. Field grown stock as received from the nursery proved unsatisfactory for forcing.

In hard wooded, deciduous plants the most satisfactory results were secured from lilacs and these were exclusively employed in all subsequent trials. In the case of herbaceous perennials astilbe japonica was found to respond most satisfactorily, although pot-grown paeonies and iris plants were forced quite successfully. Moreover astilbe was easily obtained, was comparatively inexpensive, did not require to be pot-grown, and was easily held in a dormant condition throughout the forcing season. Among bulbous and allied plants, the lily-of-the-valley was found to be quite as satisfactory as any, and at the same time was, like the astilbe, a comparatively inexpensive plant to use. The employment of cold storage stock is not to be advocated, as the pips start into growth so quickly, when subjected to the forcing conditions, as to make it practically impossible to secure much growth response through anesthesia.

LILAC

On account of the relatively high cost of the pot-grown stock comparatively few plants could be used in any one trial. Charles X. and Marie Legraye were the only varieties used. Ether, chloroform, and ethyl iodide were employed, the dosages varying from 1 c. c. per cubic foot air space (ethyl iodide) to 15 c. c. (ether). The periods of treatment varied from 24 to 72 hours. The latter treatment usually included two separate treatments, one of 48 and a second of 24 hours' duration with a 24 hour period intervening in an atmosphere freed by ventilation from the fumes of the anesthetic. This latter treatment is generally expressed in the tables thus: 48-24-24 hours.

Owing to limited greenhouse facilities and a rather low room temperature, the time required to bring both the treated and the untreated plants into bloom was considerably longer than would have been the case had it been possible to subject them to a relatively high room temperature as soon as they were removed to the greenhouse. However, it is not thought that the relativity of the results is materially affected thereby.

Six separate treatments were made at varying intervals from November 9-13, 1907 to January 22-25, 1908.

THE ANESTHESIA OF LILACS

					Charles X				Marie Legraye			
Number and date of treatment	Chemical used	Dosage; c. c. per cu. ft.	Exposure; hrs.	Date placed in greenhouse	First bloom in days	Gain, days	Full bloom in days	Gain, days	First bloom in days	Gain, days	First bloom in days	Gain, days
I Nov. 9-13 1907	None	—	—	Nov. 11	49.5		53.5		39		42	
	Ether	10	48	11	32	*17.5*	44	*9.5*	26	*13*	33	*9*
	"	10	48-24-24	13	27	*22.5*	34	*19.5*	25.5	*13.5*	31	*11*
	Chlorof'm	3	48	11	41	*8.5*	44	*9.5*	30	*9*	37	*5*
	"	3	48-24-24	13	19	*30.5*	27	*26.5*	25	*14*	31	*11*
II Nov. 18-22 1907	None	—	—	Nov. 20	45		51		28		30.5	
	Ether	12	48	20	26	*19*	31	*20*	23.5	*4.5*	29.5	*1*
	"	12	48-24-24	22	25.5	*19.5*	28.5	*22.5*	25	*3*	29	*1.5*
	Chlorof'm	3.6	48	20	27	*18*	31	*20*	24.5	*3.5*	28.5	*2*
	"	3.6	48-24-24	22	25	*20*	28.5	*22.5*	24	*4*	25	*5.5*
III Nov. 30 Dec. 4 1907	None	—	—	Dec. 2	30		35		26		29	
	Ether	15	48	2	23	*7*	30	*5*	25.5	*0.5*	32	*—3*
	"	15	48-24-24	4	24	*6*	40	*—5*	22	*4*	30.5	*—1.5*
	Chlorof'm	4.5	48	2	23	*7*	29	*6*	24	*2*	29	*0*
	"	4.5	48-24-24	4	22.5	*7.5*	26.5	*8.5*	25.5	*0.5*	28	*1*
IV Dec. 17-21 1907	None	—	—	Dec. 19	27		31		25		29.5	
	Ether	15	48	19	25	*2*	31	*0*	25	*0*	29.5	*0*
	"	15	48-24-24	21	24	*3*	28	*3*	25	*0*	--	—
	Eth. chlo.	2	48	19		kill	ed		27	*—2*	39	*—9.5*
V Jan. 11-15 1908	None			Jan. 13	23		25		21		25	
	Ether	15	48	13	21	*2*	24	*1*	22	*—1*	25	*0*
	"	15&10	48&24	15	20	*3*	24	*1*	21	*0*	24	*1*
	Eth. iodid	2	48	13		kill	ed			kill	ed	
	"	2&1	48&24	15		kill	ed			kill	ed	
VI Jan. 23-25 1908	None			Jan. 24	22		29		21		26	
	Ether	15	24	24	23	*—1*	30.5	*—1.5*	21	*0*	31	*—5*
	Eth. iodid	1	48	24	24	*—2*	29	*0*	22	*—1*	25	*1*
	"	1&2	48&24	25		kill	ed			kill	ed	

(1) *November 9-13.*—Ten plants each of Charles X and Marie Legraye were divided into five as nearly uniform lots as possible and were subjected to the following treatment:

Lot 1, untreated (control); lot 2, 10 c. c. ether for 48 hours; lot 3, 10 c. c. ether for 48-24-24 hours; lot 4, 3 c. c. chloroform for 48 hours; lot 5, 3 c. c. chloroform for 48-24-24 hours.

The average increase in earliness, or in growth acceleration, in the Charles X lilacs was 17 days with the plants etherized 48 hours, and 8.5 days for those subjected to chloroform fumes for the same time. The etherized plants came into bloom 22.5 days earlier than did the untreated, while the chloroformed plants showed a gain of 30.5 days. The Marie Legraye lilacs etherized for 48 hours showed a gain of 13 days; those which were chloroformed bloomed 9 days in advance of the untreated plants; while those treated for 72 hours gained 13.5 and 14 days respectively. These plants are shown in plates I and II. They clearly indicate the growth accelerating influence of both ether and chloroform when properly applied. The two photographs show different stages in the growth of the plants. The reader's attention is especially directed to the relative lack of foliage on the untreated plants, a difference which was usually quite marked.

(2) *November 18-22.*—Aside from slight changes made in the amounts of ether and chloroform used, the second treatment was identical to that just described. Ether was used at the rate of 12 c. c. and chloroform at the rate of 3.6 c. c. The results secured with Charles X were very similar to those obtained ten days earlier, but they were much less marked with Marie Legraye. Charles X lilacs etherized for 48 hours showed a gain of 19 days, while those etherized for 72 hours came into bloom 19.5 days earlier than did the untreated plants. The bloom of the 48 hour chloroformed plants was hastened 18 days, while that of the plants given the 72 hour treatment appeared 20 days in advance of the control. The untreated Marie Legrayes bloomed in 28 days, the Charles X lilacs took 45 days; the an-

esthetized plants took on the average 24 and 26 days, respectively. Hence in spite of the fact that the treated Marie Legrayes outstripped the Charles X in earliness of bloom, the very early blooming period of the untreated plants renders the gain in blossoming period relatively slight, the 48 hour etherized plants gaining but 4.5 days, and those treated 72 hours showing an increase of only 3 days, while the chloroformed plants were accelerated but 3.5 and 4 days respectively.

(3) *November 30-December 4.*—The ether dosage of the third lot of plants was increased from 12 to 15 c. c. and that of chloroform from 3.6 to 4.5 c. c. The results showed gains of 7 and 6 days respectively from 48 and 72 hour etherized Charles X lilacs, and 7 and 7.5 days respectively from the 48 and 72 hour chloroformed plants. The gains from the Marie Legraye plants were 3.5 and 4 days for the 48 and 72 hour etherized plants, and 2.5 a half day respectively for the chloroformed ones.

(4) *December 17-21.*—Only eight plants of each variety were used divided into four groups, and ethyl iodide was substituted for chloroform. Two and three day gains respectively were secured from the etherized Charles X lilacs. A 48 hour exposure to 2 c. c. of ethyl iodide killed both the plants. The etherized Marie Legrayes showed no gain over the untreated plants, while those treated with ethyl iodide were retarded two days.

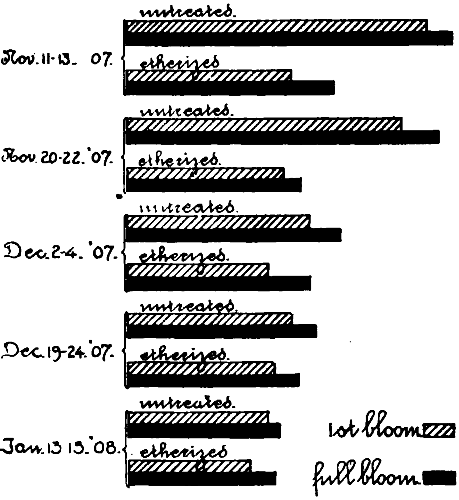
(5) *January 11-15.*—The gain in favor of ether was again comparatively slight, two and three days respectively when Charles X lilacs were used, while no gain was secured from Marie Legrayes. Both varieties were killed by ethyl iodide treatment.

(6) *January 23-25.*—No results were secured save that the blooming period was slightly retarded and the fact was demonstrated that a 1 c. c. treatment of ethyl iodide for 48 hours did not result in material injury. The employment of this chemical on hard wooded plants is not to be recommended. Similar fatalities resulted from its use on azaleas.

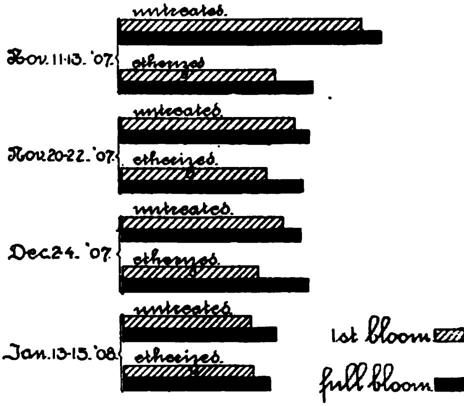
It is evident from a study of these data as a whole that after the third treatment too little growth acceleration was secured to justify the use of an anesthetic. It would seem to be demonstrated that after the early part of December the plants begin to pass out of the middle rest period and consequently do not require a powerful stimulus to start them into growth.

Another factor which no doubt militated against the securance of favorable results in the later treatments was the increment of the dosage. Had these dosages been used in inverse order, that is to say, had they decreased in amount as the rest period increased in length, the results in all probability would have been more satisfactory. Earlier treatments would have been likely to have afforded more striking results.

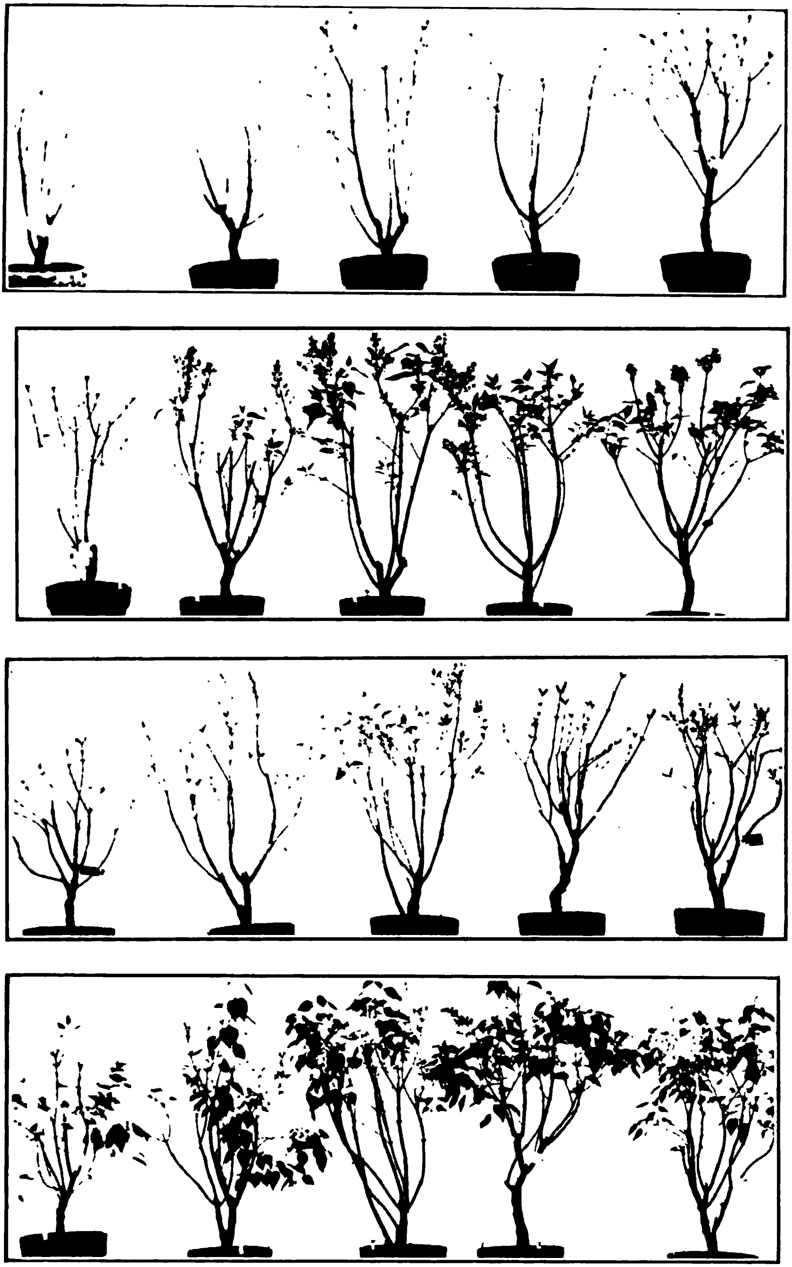
The accompanying graphic charts show the relative number of days required from the time of placing the plants in the greenhouse until they came into bloom, comparisons being made between the etherized and unetherized plants in the first five treatments of Charles X and for the first four of Marie Legraye. A study of these two charts shows that the relative growth



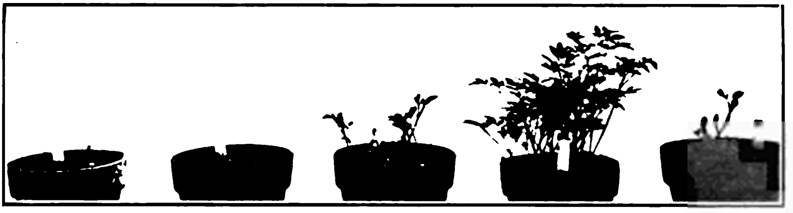
Lilac Marie Legraye; relative growth
t different dates.



Lilac Marie Legraye; relative growt
response at different dates.



Charles X. and Marie Legraye lilacs, 2½ and 4 weeks after treatment. From left to right: Control (untreated); ether, 10 c.c. 48 hours; ether, 10 c.c. 48-24-24 hours; chloroform, 3 c.c. 48 hours; chloroform, 3 c.c. 48-24-24 hours.



The effect of anesthetics on Astilbe and Lily-of-the-Valley (reading from left to right, and from upper cut to lower cut).

I II. Treated Nov. 9-11, 18-20; planted Nov. 11 and 20; photographed, upper picture Jan. 8, second picture Jan: —. Control (untreated); 10 c.c. ether 48-24-24 hours; 2 c.c. ethyl iodide 48 hours; ditto; 2 c.c. ethyl bromide 48 hours.

III. Treated Nov. 9-11, 18-20; planted Nov. 11 and 20; photographed Jan. 8. Control (untreated); 4 c.c. ethyl bromide 48 hours; 2 c.c. methyl chlorid, 48 hours; 10 c.c. methyl alcohol, 48 hours; 10 grams methyl chlorid, sprayed; 20″ vacuum 4 hours; 20″ vacuum 4 hours, followed by 10 c.c. ether 24 hours.

IV. V. Treated; first control plants Nov. 11; residue Dec. 17-21. Photographed, fourth picture Jan. 8, fifth picture Jan. 15. Control (untreated); frozen; control (untreated); frozen, 2 c.c. ethyl iodide, 48 hours; 2 c.c. ethyl iodide, 48 hours; frozen, 2 c.c. ethyl iodide, 48-24-24* hours; 2 c.c. ethyl iodide, 48-24-24* hours; frozen, 15 c.c. ether, 48 hours; 15 c.c. ether, 48 hours; frozen, 15 c.c. ether, 48-24-24* hours.

VI. Treated Nov. 25-26. Control (untreated); 10 c.c. ether, 24 hours; 1 c.c. ethyl iodide, 24 hours; 2 c.c. ethyl iodide, 24 hours; 4 c.c. ethyl bromide, 24 hours; 10 c.c. acetone, 24 hours.

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*Dosage repeated at beginning of last 24 hours; intermediate 24 hours in ventilated chamber unacted upon.

acceleration due to the ether quite rapidly diminished as the season progressed.

ASTILBE

Eight trials of astilbe were made between November 11, 1907 and February 28, 1908. The materials employed were ether, chloroform, ethyl iodide, ethyl bromide, ethyl chlorid, methyl chlorid, methyl alcohol. and acetone. The mechanical effects of freezing and of vacuum were also tested.

While these various treatments did not uniformly result in accelerated growth, in a large measure they corroborated the outcome of the lilac trials. This was particularly true with respect to the more pronounced growth response made by the earlier as compared with the later treated plants.

In order to facilitate a comparative study of the relative merits of the agents employed to stimulate growth, tables have been constructed for each period of treatment. These tables show the materials and amounts used, together with the period of treatment, and the number of days elapsing between treatments and the first leaf growth and the first flower bud.

THE ANESTHESIA OF ASTILBE

Number and date of treatment	Chemical used	Dosage in c. c. per[1] cu. ft. space	Duration, hours	First leaf growth, days	Gain in days	First flower bud	Gain in days
I	None,	—	—				
Nov. 9-13	Ether,	48	10	51	*8.5*	73.5	— *1.5*
1907	"	48-24-24	10	57	*2.5*	75	— *3*
	Chloroform,	48	3	66	— *6.5*	86.5	—*14.5*
	"	48-24-24	3	74	—*14.5*	81.5	— *9.5*
	Acetone,	48	5	47	*12.5*	63	*9*
	Ethyl bromide,	48	4	51.5	*8*	58.5	*13.5*
	Ethyl iodide,	48	2	26	**33.5*	44	*28*
	Methyl alcohol,	48	10	52	*7.5*	64	*8*
	Methyl chlorid,	48	..	36.5	*23.5*	65	*7*
	Vacuum,	3⅝	20″	59.5	*0*	72.5	— *0.5*
II	None,	—	—	47	....	68	....
Nov. 18-21	Ether,	12	48	50	—*3*	68	*0*
1907	Acetone,	5	48	36	*11*	61	*7*
	Methyl alcohol,	10	48	39.5	*75*	50.5	*17.5*
	Ethyl iodide,	2	48	14	*33*	33	*35*
	Ethyl bromide,	4	48	23.5	*23.5*	44	*24*
	Ethyl chlorid	10	sprayed	39	*18*	57.5	*10.5*
	Methyl chlorid	10	"	29	*18*	48.5	*19.5*
	Vacuum,	20″	4	35.5	*11.5*	56.5	*11.5*
	" and 10 c.c. ether	20″	24	40	*7*	56	*12*

[1] For vacuum, inches mercury.

*Through an error in copy of address published in Transactions Massachusetts Horticultural Society,[15] p. 84, table II, the heading date of bloom should read date of first leaf growth. A second error occurs in date given for first leaf growth of ethyl iodized plants. This should read December 7 instead of January 7, making the gain 33.5 instead of 2 days as noted.

Number and date of treatment	Chemical used	Dosage in c.c. per[1] cu. ft. space	Duration, hours	First leaf growth, days	Gain, days	First flower bud	Gain, days
III Nov. 30-Dec. 4 1907	None,	—	—	35	....	51	..
	Frozen,	—	—	46	*—9*	56	*— 6*
	Frozen and ether,	15	48	32	*3*	51	*0*
	Ether,	15	48	43.5	*—8.5*	53	*— 2*
	"	15	48-24-24	32.5	*2.5*	47.5	*3.5*
	Ether and vacuum,	15&20-25″	48	33	*2*	57	*— 6*
	Vacuum,	20″-25″	48	28.5	*6.5*	48	*3*
	Amyl alcohol,	10	48	22	*13*	49.5	*1.5*
IV Dec. 17-21 1907	None,	—	—	26	....	34.5	....
	Frozen,	—	—	20	*6*	35.5	*—1*
	Frozen and ether,	15	48	14	*12*	30	*4.5*
	Ether,	15	48	15	*11*	33.5	*2*
	Frozen and ether,	15	48-24-24	12	*14*	28	*6.5*
	Ether,	15	48-24-24	15.5	*10.5*	34.5	*0*
	Ethyl iodide,	2	48	14	*12*	34	*0.5*
	Frozen and ethyl iodide,	2	48	13	*13*	30	*4.5*
	Frozen and ethyl iodide,	2	48-24-24	10	*16*	29	*5.5*
	Ethyl iodide,	2	48-24-24	10	*16*	28	*6.5*
	Vacuum,	20-25″	48	16	*10*	39.5	*—5*
V Jan. 11-15 1908	None,	—	—	14	....	26	....
	Frozen,	—	—	14	*0*	26	*0*
	Frozen and ether,	15	48	11	*3*	26	*0*
	Ether,	15	48	14	*0*	26	*0*
	Ether,	15&10	48-24-24	9	*5*	23	*3*
	Frozen and ether,	15&10	48-24-24	13	*1*	25	*1*
	Frozen and ethyl iodide,	2	48	11	*3*	24	*2*
	Frozen and ethyl iodide,	2&1	48-24-24	9	*5*	22	*4*
	Ethyl iodide,	2	48	11	*3*	25	*1*
	Ethyl iodide,	2&1	48-24-24	12	*2*	26	*0*

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[1] For vacuum, inches mercury.

Number and date of treatment	Chemical used	Dosage in c. c. per[1] cu. ft. space	Duration, hours	First leaf growth, days	Gain, days	First flower bud	Gain, days
VI	None,	—	—	7	....	27	....
Jan. 23-25	Frozen,	—	—	7	*0*	27	*0*
1908	Frozen and ether,	15	24	6	*1*	24	*3*
	Ether,	15	24	6	*1*	21	*6*
	Frozen and ethyl iodide,	1	24	8	—*1*	24	*3*
	Frozen and ethyl iodide,	1&2	24&24	5	*2*	20	*7*
	Frozen and ethyl bromide,	5	24	7	*0*	21	*6*
	Ethyl bromide,	5	24	6	*1*	21	*6*
	Ethyl iodide,	1	24	8	—*1*	24	*3*
VII	None,	—	—	8.5	....	19	....
Feb. 10-12	Frozen,	—	—	8.5	*0*	20.5	—*1.5*
1908	Frozen and ether,	10	24	9.5	—*1*	19	*0*
	Ether,	10	24	8	*0.5*	19	*0*
	Frozen and ether,	10	48	8	*0.5*	19	*0*
	Ether,	10	48	8.5	*0*	20.5	—*1.5*
	Frozen and ethyl iodide,	1	24	9.5	—*1*	19	*0*
	Ethyl iodide,	1	24	8	*0.5*	20.5	—*1.5*
	Frozen and ethyl iodide,	1	48	9	*0.5*	24	— *5*
	Ethyl iodide,	1	48	10.5	—*2*	26	— *7*
	Frozen and ethyl iodide,	2	24	8.5	*0*	19	*0*
	Ethyl iodide,	2	24	8	*0.5*	19	*0*
	Frozen and ethyl iodide,	2	48	10.5	—*2*	23	— *4*
	Ethyl iodide,	2	48	12	—*3.5*	22	— *3*
	Frozen and vacuum,	20-25″	48	8	*0.5*	20.5	—*1.5*
VIII	None,	—	—	4	..	11	..
Feb. 27-28	Frozen,	—	—	4	*0*	12	— *1*
1908	Frozen and acetone,	5	24	3	*1*	12	— *1*
	Acetone,	5	24	3	*1*	10	*1*
	Frozen and acetone,	10	24	3	*1*	12	— *1*
	Acetone,	10	24	3	*1*	12	— *1*

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[1] For vacuum, inches mercury.

(1) *November 9-13.*—An analysis of table I shows a considerable uniformity between the dates of first leaf growth and first flower bud. This is notably apparent in the ether, chloroform, and methyl chlorid treatments. The greatest growth acceleration was obtained from plants treated with ethyl iodide, a gain of 33.5 days appearing in first leaf growth and 28 days in first flower bud. The next greatest gain in leaf growth, 23.5 days, was obtained from the methyl chlorid treatment, followed by acetone 12.5 days; ether (48 hours), 8 days; ethyl bromide, 8 days; methyl alcohol, 7.5 days; and ether (48-24-24 hours), 2.5 days. The chloroform treatments proved injurious causing a considerable retardation. The plants which were subjected to vacuum seemed to be neither injured nor benefitted thereby.

The ethyl iodide gave the best results, in number of days to first flower bud, followed by the ethyl bromide, acetone, methyl alcohol and methyl chlorid. The etherized and chloroformed plants showed from 1.5 to 14.5 days' retardation.

(2) *November 18-21.*—The results secured were much more uniform in the second treatment. The data presented in table II show that plants treated with ethyl iodide gave the greatest growth response, gains of 33 and 35 days respectively being secured. The next best result was obtained with ethyl bromide treated plants, from which gains of 23.5 and 24 days are recorded. Methyl chlorid treated plants[1] were third in order of growth with 18 and 19.5 days' gain to their credit.

Methyl alcohol, vacuum, and ethyl chlorid, while failing to produce as marked results as in the preceding trial, were nevertheless quite satisfactory. Ether treated plants showed slight evidences of retardation.

(3) *November 30-December 4.*—The third series of trials was, with one exception, devoted to the study of the effects of ether, vacuum and frost, amyl alcohol being the only other agent

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[1] The method of applying methyl chlorid in this treatment differed from the first in that the material was sprayed directly over the plants. They were then closed in a belljar during the period of treatment.

used. The results shown in table III indicate very slight gains, while in some instances distinct delay in growth was occasioned. All things considered amyl alcohol treated plants afforded the greatest average growth acceleration. Freezing the plants before bringing them into the greenhouse appeared to be injurious in the one case, and in the other, when etherized, they were apparently neither much benefitted nor injured. Plants subjected to a vacuum of 20-25 inches for 48 hours seemed to be slightly accelerated in growth. Both the ether and the vacuum treatments slightly delayed the appearance of the flower buds.

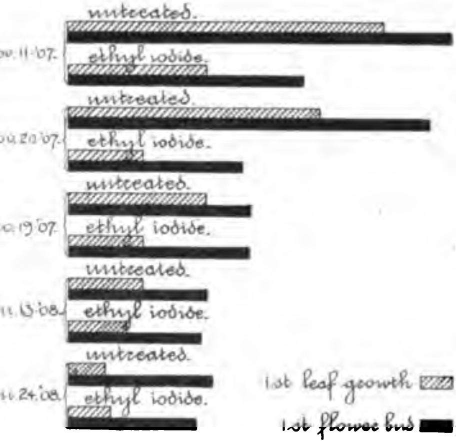
(4) *December 17-21.*—Table IV shows the results of the fourth treatment to have been slightly more satisfactory than those attained in the preceding trial. Ethyl iodide gave slightly better results than did the ether treatments, which for the first time show decidedly positive results. The average gain in earliness of first leaf growth in the four ethyl iodide treatments was 14¼ days while that from the four ether treatments was almost 12 days. In the appearance of the first flower bud the average gain was 4¼ days for ethyl iodide and 3 days for ether. Frozen plants, both treated and untreated, afforded slightly better results than did unfrozen ones. The vacuum treatment accelerated leaf growth 10 days, and delayed flower bud formation 5 days.

(5-6) *January 11-15; 23-25.*—In the fifth and sixth treatments (tables V and VI), ethyl iodide treated plants continue to show a slight gain over those which were etherized. In the sixth treatment, the gain in earliness of formation of flower bud is more marked than of leaf growth.

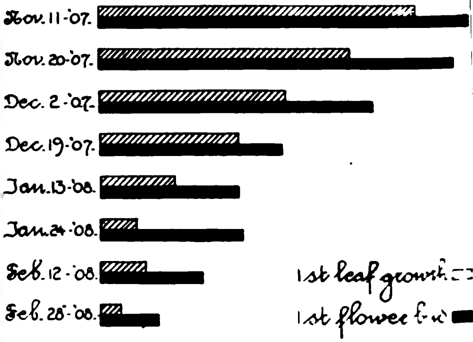
(7-8) *February 10-12; 27-28.*—The data secured during the seventh and eighth trials (tables VII and VIII) show injurious rather than beneficial results as might be expected on account of lateness of season.

Tetrachlorid of carbon was employed at the rate of 15 c. c. per cubic foot in further tests made in 1908-'09. Treatments made on December 1 and 19 for 72 hours proved that it had a much more injurious effect upon the plants than had ether, seventy-five percent of their plants being killed, while the balance were so injured that they did not develop flower buds. Through lack of further opportunity the proper dosage and length of treatment for this substance were not ascertained.

In order to illustrate more clearly the growth acceleration due to the treatment in the earlier experiments as compared with the later ones, and also, the normal growth period, curves have been plotted (page 474) in which the vertical rise of the curve from the base line A B represents the number of days required in order to bring the plant to first leaf growth or flower bud stage at any given time during the months represented, the normal growth period being always represented by a solid line. That portion of the curves which represents the situation obtaining prior to November 13 is theoretically assumed to represent the curves which would have been obtained had experiments been undertaken at an earlier date. They are presented more with the idea of suggesting the desirability of learning more regarding the actual rest periods of plants grown under normal forcing



Relative rate of growth of untreated and ethyl iodized astilbe plants at different dates.



Graphic chart showing relative norma rate of growth of astilbe japonica at different stages of the resting period. Note the marked decrease in time required to fir flower bud from Nov. 11, '07, to Feb. 28, '0 conditions than of intimating their absolute validity. It should be quite possible to determine the earliest period at which flower buds, or in the case of such plants as astilbe the crowns, are sufficiently developed to force into bloom or new growth, and then to follow this period through the rest stages. Such a knowledge would very materially assist the plant forcer in determining the earliest period at which he could hope successfully to force dormant plants. It would also give him some suggestion as to the probable growth acceleration to be obtained from the use of anesthetics or other stimulants.

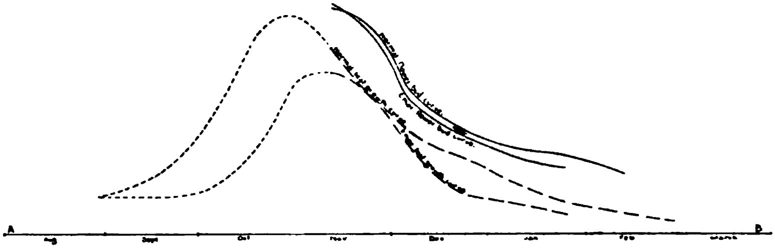
These graphic charts merely serve as another means of illustrating growth acceleration presenting in a somewhat different, more condensed and perhaps more concrete form of the data furnished in tables I to VIII and in the plates on page 472.

LILY-OF-THE-VALLEY

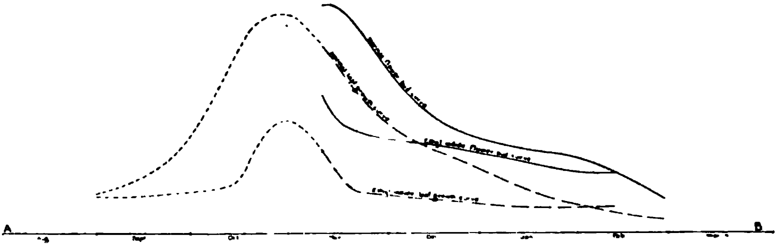
A three years' study of the exposure of pips to anesthetics or other agents shows that while in many instances marked growth response was secured, there were also a good many instances in which little, if any, acceleration was noted.

In one of the 1906-'07 treatments rather more favorable results were secured from the use of acetone than from ether, while in two other treatments the results were unsatisfactory. In 1907-'08 the most favorable results, all things considered, were obtained with ethyl iodide and ethyl bromide. Ethyl iodide, used at the rate of 1 to 2 c. c. for 24 hours, gave very favorable results. Ethyl bromide, used at the rate of 4 c. c for 24 hours, did not afford quite as good satisfaction. Ether was less satisfactory than either of the preceding fluids, while the acetonized plants were retarded.

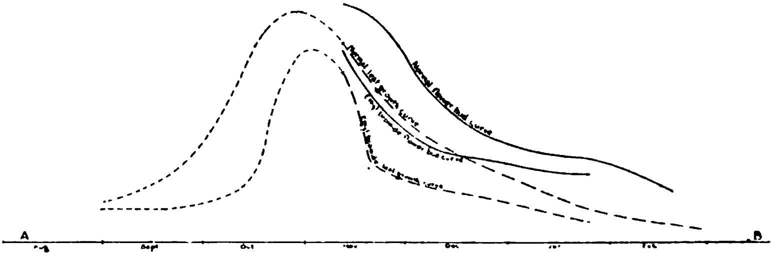
The average gain that may be expected from judicious treatment with anesthetics such as ether, chloroform, ethyl iodide or ethyl bromide ranges from 2-5 days. Such gains can only be secured with good strong pips, the use of small dosages, and comparatively short periods of treatments.



Ether flower bud and leaf growth curves compared with normal. (Astilbe.)



Ethyl iodide flower bud and leaf growth curves compared with normal. (Astilbe.)



Ethyl bromide flower bud and leaf growth curves compared with normal. (Astilbe.)

Curves of leaf growth and flower bud development from untreated and treated plants of astilbe japonica.

That portion of the leaf growth curves prior to Nov. 11 is purely hypothetical, the remainder is constructed from known data.

The vertical height of the curve at any given point from the base line A B represents the approximate number of days required to first leaf growth or first flower bud.

Paulig (13) found that a 12-16 hour immersion of lily-of-the-valley pips in water at 95° F. hastened the blooming period of the plants from 4-5 days over those not treated. From this it would appear that the warm water bath method may be used with quite as satisfactory results as are obtained from anesthetics.

In view of the fact that lily-of-the-valley pips ordinarily force easily and quickly under normal conditions, there does not appear to be much advantage in the employment of artificial aids to accelerate their growth unless it be with freshly harvested plants. Cold storage pips are little benefited by treatment.

BULBOUS AND MISCELLANEOUS PLANTS

Although many treatments were made while the investigation of growth accelerating agents was being pursued, the results secured were too conflicting to warrant either permanent record or generalization. In some instances, such as that of the amaryllis, the growth response was quite marked, and in direct relation to the intensity of the treatment. Paeonies and iris generally showed leaf growth acceleration, but in most cases the stimulus was not projected to the flowering stage. There were quite as many failures as successes recorded in the attempt to accelerate the growth of narcissi and hyacinths. These results are not in accord with those secured by Lewis (10) and Taubenhaus (16). Lewis reports very satisfactory results in the etherization of narcissi bulbs, the time gained being from two days to about three weeks. Taubenhaus intimates, regarding the effect of ether on roman hyacinth bulbs, that it was "to hasten the blooming period; to improve the quality of flower and size of the stem; and to increase the amount of flowers," gains of from 1-7 days being secured.

While the results of the experiments with bulbs were unsatisfactory, the writer does not feel justified in concluding that bulbous plants do not respond favorably to anesthetics. The work of Lewis and Taubenhaus demonstrates that it is possible to secure growth acceleration by the use of ether. It is believed, however, that the employment of ether or other substances as an aid to bulb forcing is not of sufficient practical importance to warrant its use by the commercial grower.

(3) THE OPTIMUM DOSAGE AND MOST EFFECTIVE PERIOD OF TREATMENT

In order to secure a maximum growth acceleration from the use of anesthetics or other toxic substances in the treatment of plants in a state of rest, it is quite important to determine the optimum dosage and most effective period of exposure to the vapor of the liquid used. Experience has shown that the amount varies with the season of the year in which the plant is treated, the period of exposure, temperature of the inclosed air, and the class of plant used. In the "before" and "after rest" periods the dosage used should be less than during the early portion of the "middle rest" stage. A reduction in dosage should also be made if the temperature of the inclosed air exceeds 60-65° F., and, per contra if it falls below 55° F. the dosage should be increased. In this connection Johannsen says: "The influence of the ether upon the plant varies greatly with the temperature. The higher the temperature the stronger its influence. An amount of ether which has no effect at a temperature of 32° F. will injure the plants very seriously at a temperature of 86° F."

During the time in which the plants are passing into and through their most intense rest periods they should be exposed to the vapor of the substance used for from 48 to 72 hours and in some cases even to 96 hours. Generally in the longer exposures the plants are subjected to two separate treatments; the first for 48 hours, followed by a 24 hour exposure to the free air, after which the case or receptacle is again closed and a second dosage administered for 24 or 48 hours as the case may be. Later in the season the time element may be decreased to two 24 hour exposures, or even to a single 24 hour period.

A dose of ether may vary from 5-15 c. c. per cubic foot of air space enclosed. Usually from 10-15 c. c. are employed.

Occasionally a larger dose may be used. Maumené (11) recommends the following amounts of ether per cubic foot of air space:

Lilacs, 13.7-15.7 c. c.; azalea mollis, 13.7-15.7 c. c.; viburnum opulus, 14.8-16.4 c. c.; prunus persica, prunus triloba, prunus sinensis, 11.7-13.7 c. c.; spiraeas (varieties), 12.5-14.8 c. c.; deutzia gracilis, 13.7-15.7 c. c.; lilies and lily-of-the-valley, 13.-15.7 c. c.

The writer's experience with lily-of-the-valley leads him to recommend not over 10 c. c. of ether per cubic foot of air space. Better results have been secured with this amount than with larger doses. Doses of other anesthetics, per cubic foot of air space, as employed by the writer are:

Chloroform, 3-4 c. c.; ethyl iodide, 1-2 c. c.; ethyl chlorid,[1] 2-3 c. c.; ethyl bromide, 3-4 c. c; methyl chlorid, 2 c. c.; methyl

TREATMENTS RECOMMENDED FOR PLANTS AT DIFFERENT SEASONS

	OCTOBER		NOVEMBER		DECEMBER		JANUARY	
	c. c. used	for hours	c. c. used	for hours	c. c. used	for hours	c. c. used	for hours
Lilacs								
Either ether	15	48-24-24	12	48-24-24	10	48-24-24	..	..
or chloroform,	4	"	3½	"	3	"	..	..
Astilbe								
Either ether	15	48-24-48	15	48-24-24	12	48-24-24	10	48
or chloroform,	4	"	4	"	3½	"	3	"
or ethyl iodide,	2	"	2	"	2	48	2	24
or ethyl bromide,	4	"	4	"	4	"	4	"
Lily of the valley								
Either ether	10	48	10	48	10	48	10	24
or ethyl iodide,	2	"	2	"	2	24	1 to 2	24
or ethyl bromide,	4	"	4	"	4	24	3	24

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[1] Ethyl chlorid may be used in the ordinary way or it may be used as a spray. On account of its very low boiling point it is a difficult substance to handle and its use is not advised.

alcohol, 10-15 c. c.; acetone, 10 c. c.; tetrachloride of carbon, 10 c. c.

The best temperature at which to treat the plants is in the neighborhood of 60° F. It may vary between 55° and 65° F. without materially influencing the results. If higher temperatures prevail, the dosage or the period of treatment, or both, should be reduced accordingly.

SUMMARY

Anesthetics, when properly applied to plants in a state of complete rest, impart a decided growth impulse.

Toxic substances such as alcohol, acetone, and other similar agents while not causing insensibility, unless employed in large amounts, act much the same as do anesthetics and cause a more or less decided growth acceleration. The application of frost and vacuum result in some instances in accelerated growth, while in others negative results are obtained.

Ether and chloroform seem to afford the most satisfactory results with lilacs; which ethyl iodide and ethyl bromide yield a better outcome with astilbe and with lily-of-the-valley than do such other materials as have been used.

Lilacs are most effectively treated prior to December 1. After this date the growth acceleration is less marked. Apparently the lily passes from the "middle rest" to the "after rest" period during the latter part of November.

Astilbe treatments made after January 1 were much less effective in accelerating growth than those made prior to this date. The time of passage to the "after rest" period is assumed to be in the latter part of December.

The effect of anesthetics and other substances upon bulbous plants was not sufficiently definite to warrant deduction.

The desiccating effect of ether and chloroform upon bulbs was more marked than that secured with methyl alcohol and acetone.

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UNIVERSITY OF VERMONT
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VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 151

APRIL, 1910

"Buddy Sap."

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BULLETIN 151: "BUDDY SAP"

A Preliminary Report Upon the Micro-organisms Occurring in Maple Sap and their Influence Upon the Quality of Syrup

By H. A. Edson[1]

SUMMARY

Maple sap as it occurs within the tree is free from bacteria and other micro-organisms.

As the sap flows from the tree it becomes infected, in the taphole, spouts and buckets, with wild yeasts, spores of molds, and countless numbers of bacteria. . This infection becomes increasingly heavy with the advance of the sugar season and is the cause of the "souring" of sap.

Some of the types of hurt sap are caused by the action of specific groups of organisms, others may be caused by the collective action of many of the common forms.

Green sap and the resulting red syrup are not to be attributed to the swelling of the buds, but are caused by the development of a particular group of bacteria characterized by green fluorescence.

The dark color of the late run syrup is due entirely to the action of micro-organisms. If these are eliminated, as light colored syrup may be made from the last run as from the first run.

The flavor of the syrups is also seriously impaired by these agents. This injury often becomes pronounced before marked change in color is produced. "Buddy" flavors also appear to be due, at least in part, to the action of micro-organisms.

The quality of the product may be improved by: (1) keeping the spouts and buckets thoroughly clean; (2) using metal utensils in lieu of wooden ones; (3) gathering the sap at short intervals and boiling it in at once.

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[1] The author is indebted to Messrs. C. W. Fitch of the class of 1910 and C. W. Carpenter of the class of 1911 for faithful and efficient aid in field and laboratory work.

INTRODUCTION

Vermonters are familiar with the conditions under which maple sugar is produced, but for the sake of such readers as know little or nothing about "sugaring off," a brief description of the sap flow and of sugar making as practised in Vermont precedes the body of this article.[1]

Late in March, in this section, evidences of the coming spring appear. The nights are still cold and frosty but the days are genial and the temperature rises a few degrees above the freezing point. If, at this time, the trunk or limbs of certain species of the genus *Acer* are fresh wounded a sweet sap exudes. The Indians were familiar with this phenomenon before white men came; and had learned to collect, to concentrate and to make sugar from this sap. The early settlers[2] learned from them the essential steps which, in modified form, constitute the procedure followed in the maple sugar industry today.

According to modern practice the tree is tapped by boring a half inch hole 2 inches deep about 4 feet from the ground. A round, hollow spout or "spile" of wood or metal, upon which is suspended a bucket to catch the dripping sap, is driven into the hole. The sap flow is not continuous but is divided into short intermittent periods, technically termed "runs." It occurs only during the three or four weeks which immediately precede the unfolding of the leaf buds. Both its periodicity and its duration depend upon weather conditions. The sap is more likely to flow in the daytime than at night; and the more important runs are confined to what are spoken of as "good sap days." These occur only after the air temperature has remained below freezing for some time. If, following such a cold spell, the temperature rises materially above 32° F. a good run is likely to ensue. Excessive warmth and high winds check the flow. Freezing nights followed by moderately warm, cloudy days, and the absence of excessive sunshine and heavy winds, are the meteorological conditions which characterize the best sugar weather. So long as the air temperature remains essentially constant, whether warm or cold, little or no sap is obtained.

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[1] For a comprehensive discussion, see Vt. Sta. Bull. 103 (1904).
[2] Garden and Forest 4, p. 171.

The buckets in which the sap is caught are made of wood, tin or galvanized iron; and, in the better works, are covered to keep out rain, snow and other foreign material. The sap is collected after each day's run and taken to the boiling house, technically known as the sugar house, where it is concentrated into syrup in large shallow pans over a roaring wood fire as rapidly as the capacity of the equipment will permit.

Maple sap is a sweet liquid containing a varying amount, averaging from 2 to 3% of saccharose, and, usually, traces of invert sugar. In addition to these carbohydrates it contains small amounts of proteids, of mineral matter, mainly lime and potash, and of acids, mainly malic acid. The sap of the earlier flows is water clear and transparent, and possesses a clean, sweet flavor. With the advance of the season however it undergoes a marked change. As the days grow warmer and night freezes are less severe and less frequent, the sap gradually becomes cloudy and discolored and unpleasant flavors develop. Such sap, while usually containing only the normal amount of acid, is popularly termed "sour." It rapidly deteriorates when stored even for a few hours. Several types of sour sap are recognized by sugarmakers, to which the descriptive terms "milky," "stringy," "red," and, particularly, "green" are commonly applied. Green sap is almost always secured just before the close of the season, when the leaf buds are ready to open. It is popularly believed that the swelling of the buds, associated with the renewal of vegetative activity in the tissues of the tree, is accompanied by a change in the composition of the sap within the trunk; and that the alteration in color and flavor are manifestations of this change. The term "buddy" is universally used to describe this sort of sap.

The syrup made from late runs is much inferior to that derived from the earlier flows. "Last run" goods are often very dark in color and usually lack the delicate flavor possessed by the best syrups. Moreover, the quality of syrup varies markedly from year to year and these variations are seldom local in distribution. Such widespread fluctuations in quality are not accidental but of necessity must be associated with some fundamental cause or causes. It is conceivable that they may be related to weather conditions, either during the preceding summer or during the progress of the sugar season. It is known, moreover, that inferior products result from carelessness and lack of cleanliness in collecting and handling maple sap. Such procedures must occasion a great increase in the bacterial content of the sap, just as in dairying they entail serious bacterial contamination in milk. The proteid, carbohydrate and mineral contents of maple sap are sufficient to make it a fairly good medium for the development of bacterial life, provided suitable temperature relations are maintained; and the vital activities of large numbers of micro-organisms would presumably affect the flavor and quality of the syrup produced under such conditions.

Reflection upon these facts strongly suggests the possibility that micro-organisms may be associated with the inferiority of the maple output in all the cases cited, or that, indeed, they may be the direct cause of the troubles. Inevitably they must be present in the sap and it is to be expected that they would be more abundant toward the close of the sugar season than earlier, because the warmer weather would favor their increasingly rapid development and multiplication. It is conceivable that the "off" seasons may prove to be those wherein conditions foster this microscopic life to an unusual degree. More favorable temperature relations, or longer periods of incubation, or both, in "off" years and in the latter part of the season, might reasonably be expected to promote the multiplication of organisms in the taphole, spout and bucket, thus producing heavy initial inoculation of the sap. Uncleanly methods would certainly result in this condition, and in any case, storing, even for a short length of time, would serve to increase the troubles due to the vital activities of microscopic organisms, particularly if the temperature of the storage house was considerably above the freezing point, as is apt to be the case.

Restating the proposition in the form of queries: What is the cause of the deterioration of maple sap? Is it due to changes in its composition occurring within the tissues of the tree as a result of the resumption of vital, protoplasmic activities and the renewal of vegetative vigor; is it due to the action of micro-organisms entering the sap after it leaves the vascular bundles of the trunk; or is it to be attributed to a combination of these causes?

The experimental work, upon which a preliminary report is submitted in these pages, was undertaken in an effort to determine so far as might be possible, the answer to these questions; and attention was first directed to a study of the micro-organic life in maple sap and its influence upon the quality of the sap and of the syrup produced from it.

THE EFFECT OF MICRO-ORGANISMS UPON THE KEEPING QUALITY OF SAP

Early in April, 1907, sap was drawn from a tree under ordinary conditions, and placed in bottles of about 350 c.c. capacity, closed with cotton plugs. One-half of these bottles were heated at the temperature of boiling water in a steam chamber for a half hour on each of three consecutive days, to kill any living organisms which might be present. A very little sediment precipitated from the sap during this treatment; otherwise, it remained unchanged in appearance. Some two or three weeks after the last heating these bottles were capped with sealing wax to prevent evaporation. They have been stored on laboratory shelves since that time without undergoing perceptible change. The flavor of the sap in bottles opened after 30 months was unchanged. The unsterilized sap on the contrary, promptly became turbid and developed one or another of the various types of so-called souring previously mentioned. Microscopic examination revealed the presence of multitudes of bacteria, as well as the spores of molds and yeasts.

DRAWING STERILE SAP FROM THE TREE

That these micro-organisms originated without rather than within the tissues of the tree seemed highly probable; but in order to demonstrate this point, and also to learn whether the preservation of the sterilized sap was due entirely to the absence of micro-organisms, or whether it was due in part to chemical changes induced by sterilization,—such for instance as the destruction of enzyms—an attempt was made to draw fresh sap in a sterile condition. Threads were cut upon each end of a straight piece of half inch gas pipe about 5 inches in length and a set nut was fitted on one end. This device was used as a spile. Threads were also cut on the larger end of a 9 inch tube, half inch in diameter at one end and three-eighths inch at the other, which was used as a delivery tube. The end of the spile not carrying the set nut and the larger end of the delivery tube were connected by a short piece of tightly fitting, flexible rubber tubing. This device constituted the conducting apparatus. Absorbent cotton was wound around the small end of the delivery tube until it was of such size as would enable it to fit tightly into the neck of the bottle used as a container. Care was taken to protrude the delivery tube an inch or more beyond the cotton. Above the cotton plug a sheet of cotton batting was fastened in such a manner as to form an umbrella like covering long enough to reach to the bottom of the bottle. When ready for use, the device resembled a limp and partially closed umbrella, the delivery tube placed in the mouth of the bottle being comparable to a hollow umbrella handle, and the sheet of cotton to the cover. Prior to use, both ends of this apparatus were wound with sheets of absorbent cotton and the entire device placed in the autoclave and sterilized by heating for 30 minutes under a pressure of 10 pounds of steam. The collecting bottles were plugged with cotton and sterilized in the autoclave. The bit used later in tapping the tree as well as the shave for removing the outer bark were sterilized and immersed in boiling water, in which they were kept until the instant of use. The tree was shielded from the wind during the process of tapping. The rough bark was broken away with a hammer and, by the use of the sterile shave, the corky material was removed until only a thin portion remained. The shave employed was dipped in boiling water after each stroke; and as an added precaution the area thus prepared was finally washed with formalin, and then dried by the heat from an alcohol torch. Then a hole was bored to a depth of 2.5 inches, using the sterilized bit. An assistant removed the free end of the 5 inch length of gas pipe from the cotton covering at the instant the bit was removed from the tap hole, and inserted the spile into the tree. A pipe wrench was used to turn the set nut firmly against the trunk. Great care was taken in this operation to eliminate contamination from the hands, the air or the tree bark. With equal precaution the outer wrapping of cotton was removed from the delivery tube, and the end of the conducting apparatus thus freed was inserted into the neck of the collecting bottle, so as to bring the cotton plug into position. The bottle was then placed in a rack upon a support prepared for it, and protected from accident by a shield. The work of tapping and setting up the apparatus was carried out before the sap started and while the tree was still frozen, in order to avoid the disadvantages which would result from the presence of liquid sap. As fast as the collecting bottles were filled they were removed and others were subsituted. The exchange was carried out with extreme care in order to prevent contamination of the interior of the delivery tube or of either of the bottles. The sterile cotton plug of the fresh receptacle was transferred to the full one at the same time that the delivery tube was changed. The operation was carried out under a shield of sterilized cotton so as to prevent as far as possible contact with currents of unsterilized air.

The first tree was tapped March 18, 1907 at 8.30 a. m., while it was frozen. There was no flow of sap from this tree until the afternoon of March 25, when two bottles were obtained in sterile condition. On March 30 and on April 3 other trees were tapped in the same manner. Sap was obtained in several bottles in which no development of bacteria, yeasts or molds occurred. In a certain percentage, however, as was to be expected, growth developed; but this is to be attributed to some slip in the technique, such as contamination incident to changing bottles or infection in the tap hole made possible through expansion and contraction accompanying changes of temperature. The sap in which no contamination occurred has remained unchanged in appearance and in flavor up to the present time, (February, 1910), an interval of nearly 35 months.

These results seem to justify the opinion that the "souring" of maple sap is in no degree a process of auto-decomposition, but, rather, one to be attributed entirely to the action of living organisms.

ISOLATION OF ORGANISMS

The contents of such bottles of sap as did not keep, that is to say which showed clouding or "souring," were examined for bacterial contamination. Organisms were found to be present in abundance. Pure cultures were obtained by plating upon ordinary nutrient agar and also upon a synthetic medium made up as follows:

Water	1000	parts.
Dextrose	100	"
Peptone	20	"
Ammonium nitrate	2.5	"
Magnesium sulphate	5	"

Potassium nitrate	2.5	parts.
Potassium phosphate	2.5	"
Calcium chlorid	0.1	"
Agar	15	"

The first of these media, the nutrient agar, is designed especially for the cultivation of bacteria, while the second, the synthetic medium, inhibits the growth of most bacteria, but is very favorable to the development of yeasts and molds. A large number of plates were poured with each of these media and an attempt was made by examining and comparing the appearance of the colonies which developed to determine the predominant organisms. Pure cultures of these dominants were secured and reserved for further study. Various samples of normal sap drawn under ordinary conditions were examined for micro-organisms in a similar manner and pure cultures of the more common ones secured. Among the organisms thus obtained were green molds belonging to the genera *Penicillium* and *Eurotium;* a few wild yeasts; and many of the saprophytic bacteria, among which those producing fluorescent colonies were the most common type.

HURT SAP

Shortly before the opening of the sugar season of 1908 a letter was sent to a few representative sugarmakers in different sections of the state requesting samples of any unusual sap which might be found in the buckets during the coming season. Especially were samples of stringy sap, sour sap, or other abnormal material solicited. Among the considerable number of samples thus secured, all of the more common forms of hurt sap were found, such as stringy sap, red sap, and green sap, as well as milky forms of so-called sour sap. As soon as each sample reached the laboratory it was immediately subjected to microscopic examination, and was plated upon both the synthetic and the nutrient agar. Cultures of the more abundant organisms were secured, and replated as many times as was necessary to insure purity, and the final result retained for further study.

Stringy sap: One of the samples received was decidedly milky and stringy, and possessed a strong characteristic odor, suggesting yeast. The microscope revealed great swarms of actively motile bacteria, but no yeasts were discovered, either in the sediment or in the liquid portions. Plating served to develop bacterial colonies only, and these were practically all of one type. Pure cultures of this organism were isolated April 24, 1908. Subsequent inoculations have shown it to be capable of reproducing the peculiar condition occurring in the sample submitted. Its development was accompanied by mild acid formation and slight gas production. The cultural and morphological characters of this organism, which is believed to be a new species, have been studied and the results are to appear in a subsequent bulletin.

Green sap: Under this head are included all those types of hurt sap which possess a greenish or greenish-brown color. A large number of the samples submitted were of this character. Microscopic examination showed them to contain micro-organisms, frequently of several different types. The colonies developing on poured plates were always of more than one type, and in many cases included yeasts and molds as well as bacteria, though the latter were very much more numerous. The type of colony most frequently secured was of a green fluorescent character. In many cases 90 percent or more of the colonies were of this type. Critical studies of such bacteria of this class as have been isolated are under way, but the results are not yet ready for presentation. The organisms are all members of the *Pseudomonas* group, and appear to be more or less closely related to *Pseudomonas fluorescens.* Both the liquifying and non-liquifying types are included. None of these organisms ferment carbohydrates nor do they produce acid, either in maple sap or in the artificial carbohydrate media tested. Inoculation experiments reported on page 499 show that the different members of this class thus far studied are capable of producing green clouding of maple sap. The indications are that they feed upon the traces of proteids present in the sap, while they leave the sugars unchanged, or at least unfermented.

Red sap: A few samples contained a reddish brown sediment, which, upon agitation, gave to the whole volume a red color. This material was especially rich in yeasts, though the fluorescent bacteria already described were also abundant. The red color appeared to be due to a development of certain yeast-like organisms which formed red colonies. Associated with them were other yeasts or yeast-like bodies which developed gray colonies. Both of these organisms have been found to occur very commonly in the saps which have been studied now for several seasons. They appear to be widely distributed in the sugar woods of the state. Neither of them seems to be capable of fermenting the common sugars, dextrose, lactose and saccharose. Inoculation experiments with these organisms are reported on page 502.

Milky sap: Certain samples submitted had the characteristic cloudy appearance and unpleasant, slightly bitter flavor of the green types, but in place of the greenish yellow tinge showed a pale milky hue. A relatively large proportion of the colonies of organisms isolated from those saps were of a pearly white character, distinctly different from those already mentioned. Inoculation experiments were carried out with these organisms in the same manner as with the other groups (page 500). Acid and gas production were both absent in cultures grown in sap or in any other of the carbohydrate media employed during the preliminary studies.

Molds: Constantly associated with other organisms in sap there occurred a certain number of mold spores. These were seldom found in any great number, but because of their universal appearance upon the plates, pure cultures were secured. These belong to the genera *Penicillium,* and *Eurotium,* the common green molds. Inoculation experiments indicate that these molds may be of some importance in causing the inversion of sugar. See page 502.

FIELD STUDIES ON THE NUMBER AND CHARACTER OF MICRO-ORGANISMS IN MAPLE SAP

In connection with the 1909 field studies (reported on pages 496-507), as much attention as circumstances permitted was given to making further observations on the numbers and character of micro-organisms present in sap, using material secured from several sugar places at various intervals during the season. The time available for this study was so limited that only a few determinations could be made; but the results obtained are so significant that it seems best to present them in this preliminary report. It is planned to continue studies of this nature as opportunity permits.

The predominating organisms found during the earlier days of the sugar season belonged to the yeast-like group, while bacteria were relatively few in numbers. As the season advanced these conditions were reversed. Plates were poured on March 2, employing the synthetic agar upon which most bacteria do not develop, and also a nutrient agar adapted to the growth of yeasts, molds and bacteria, but especially to that of the latter. The number of organisms developing on synthetic agar in the material obtained from four different trees was 610, 500, 140, and 220 respectively, per c.c. These figures represent the yeast and mold content of the saps. The counts from the same sap plated upon nutrient agar showed the presence of 900, 1000, 140 and 220 organisms per c.c. respectively. The colonies developing upon nutrient agar included many yeasts as well as bacteria, hence it is evident that the bacterial content of these saps was low. It is also significant that few fluorescent colonies were found. Many of the series of agar plates show none of this group.

Trials made April 4 gave the following results: The sap from tree 1, on synthetic agar developed 44,000 colonies per c.c., chiefly of two types, the gray and red yeasts previously described. On nutrient agar 66,600 colonies appeared, a few of which were of the green fluorescent type. The sap from tree 2, on synthetic agar, showed a count of 1100 colonies, chiefly molds. On April 6 the sap from tree 1 showed a development of colonies on synthetic agar so numerous that they could not be counted. Its content, however, must have been over a million per c.c. On plain agar 200,000 colonies developed. Tree 2 on the same date on synthetic agar, gave a count of 2,700, and on plain agar a count of 2,600 per c.c. The types of colonies developing were similar in character to those reported from the same trees two days earlier. Attention is called to the fact that an incubation interval of six days was required for the development of the colonies reported. Upon one of these plates a few colonies of the green fluorescent type of bacteria appeared within 36 hours, but there was no sign of other colonies until the fourth day. The majority of the organisms in this sap, therefore, belonged to slow growing types, and their influence might be almost imperceptible under ordinary conditions.

Plates were poured April 12 with a view of determining the number of bacteria present; but notwithstanding the use of a dilution of 1 to 100, it was entirely impossible to count the colonies which developed. They made a rapid growth and, significantly, fluorescence was detected in the medium even before visible colonies had developed. The majority of the colonies must have belonged to the green fluorescent type. Yeast colonies were found on a few of the plates, but only in small numbers.

On April 15, plates were poured from the sap of five trees which were running sour. No attempt was made to determine the number of bacteria present, since facilities for making the proper dilutions were not available. The sap from one of these trees was of the milky type, while that from the other four trees was of a yellowish green or brown type of souring. The predominating organism in the milky sap developed pearly white colonies. The predominating organisms in the green samples were nearly all of the blue-green or yellowish-green fluorescent type. The number of fluorescent bacteria so far exceeded that of the other types as to closely approach a condition of pure culture. On the day following samples from other trees in various sugar places where the sap was "running green in the buckets" were plated, to see if these results would be confirmed. Without exception it was found that the green fluorescent bacteria were present in enormous numbers. These observations suggest that the green color may be due entirely to the presence of bacteria rather than to the swelling of the buds with which it is so often associated. Additional evidence was secured upon this point in the experiments reported upon page 504 under the heading "late run syrup."

INOCULATION EXPERIMENTS

The results of the earlier observations suggested so clearly the relationship between bacterial infection and abnormality of maple products, that it seemed advisable to conduct inoculation experiments to determine definitely its influence upon their quality.

The sugar orchard in which the field experiments were carried out is situated upon a western slope, but is exposed to north winds. The soil for the greater part is wet, and the orchard has had the reputation of producing a grade of syrup of medium standard both in flavor and color.

One hundred trees were tapped on March 24, 1909, galvanized iron Warner spouts and clean tin buckets with japanned sheet iron covers being used. The sap used for inoculation was collected late in the afternoon in clean tin cans, such as are commonly used for transporting milk, and carried directly to the field laboratory. It remained in the cans over night at a temperature just above 32° F. The next morning it was placed in new tin buckets in several 16-quart portions. One of these was reserved for a control, while each of the others was inoculated with 70 c.c. of 24-hour old cultures of bacteria or other organisms, as the case might be. At the same time 70 c.c. of sterile culture media of the same composition was added to the control. The inoculated saps and the control were placed in a room where the temperature varied during the day from 65-70° F. dropping at night to about 40° F. After three days the various portions were made into syrup, each of the several saps being evaporated in a bright sugaring-off pan on a kitchen stove until condensed to the volume of about one quart. This was then transferred to a white, agate-ware basin, and evaporated as rapidly as possible until the proper concentration, as indicated by a thermometer, was reached. The process, from cold sap to syrup, required about an hour and a half for its completion. The syrups, each about one pint in volume, were transferred at once to glass jars and sterilized by heating in a steam chamber at the boiling point of water for one hour and sealed. They were then stored in the dark until such time as they could be subjected to chemical analysis and scored for flavor and color. In order to eliminate the personal element the assistance of a commercial expert, unfamiliar with the history of the various samples, was secured to score the goods. Three grades of color and as many of flavor, were recognized, which may be considered to correspond respectively to good, poor and very poor. In addition to this general classification an attempt was made to select the sample or samples which in the opinion of the judge represented the finest and the poorest products. These special cases will be noted in the discussion of the respective series in which they occur.

A series of color charts was also prepared. These, while they do not represent exactly the true shades of the syrup, are at least comparative and give an adequate idea of the relative colors. It is greatly to be regretted that it is impracticable to reproduce these tints in this bulletin.

While it is true that pure cultures were not maintained during the progress of these inoculation experiments yet it is believed that, in the case of the bacterial cultures at least, a sufficiently heavy inoculation was produced to insure an overgrowth of the specific organisms under investigation. While the possible influences of other organisms naturally present must not be overlooked, it seems safe to conclude that the several results obtained are due largely to the several organisms artificially introduced, for the controls were subjected to the same natural inoculations as were the other samples.

The organisms used in these inoculation experiments were:

A. Six different cultures selected from the green fluorescent group.

B. Two different cultures selected from the other types of sour sap, and one slime producing organism obtained from a sample of stringy peas.

C. The stringy sap bacillus.

D. Five undetermined yeast cultures and one green mold.

With the exception of the stringy pea organisms the cultures employed were obtained from maple sap as already explained. It was considered important that inoculation experiments be conducted upon the first run. This, however, proved impossible, since only about 20 gallons of sap were obtained from the trees on the first day. That obtained on March 24 was used as far as it would go. March 25 and 26 were stormy days, but a light run occurred March 27. Care was taken on that morning that all buckets should be empty and clean, so that the sap then gathered should correspond as closely as possible in every way to that obtained in the first run March 24. The inoculations reported under series A, B, and C were carried out with this material. Series D was carried out on sap obtained on April 1 in the same manner as already described for the first run,[1] and inoculated April 2.

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[1] The numbers employed in the following discussion have no reference to the order in which the samples were produced. They are those used in the laboratory in connection with the scoring and analysis, and were assigned as a matter of convenience to bring related samples into consecutive numerical relation.

SERIES A. GREEN SAP BACTERIA

Six of the typical organisms producing green fluorescent colonies were selected as representatives of the hundred or more cultures of this class which had been isolated. These will be discussed under the numbers 7-12, inclusive. Within six hours after inoculation the saps numbered 8 to 12 inclusive developed a greenish color which was particularly noticeable on looking down through the sap in a good light which was reflected back from the bottom. A similar appearance developed in 7 at a later hour. All of the samples became turbid and displayed a yellowish green fluorescence in some lights. At the end of the incubation period the samples were titrated with N/100 sodium hydroxid to determine the production of acid if such occurred. The results in all cases agreed very closely with those obtained with the check, both at the beginning and at the end of the incubation period. Fermentation tubes of sap inoculated with these several organisms and held under observation along with the material to be evaporated showed no signs of fermentation.

The syrups obtained from the saps thus inoculated presented a striking contrast with the control syrup (No. 2). All were very dark colored, with a noticeable admixture of red. They were all ranked as second grade goods—in color—save one, No. 10, which was deemed to be of first grade. This sample, while much darker than the control, was somewhat less muddy in appearance than were the rest of the series. The flavors were injured even more than were the colors. No. 7 was scored third grade, ranking with one other as the poorest syrup made during the season. The rest of the series were deemed to be of second quality. The control syrup, (No. 2) was scored as first quality, both in color and flavor. It was in every way a gilt-edge product, being the best single sample obtained during the season. Chemical analyses showed that the reducing sugar content of the inoculated syrups were slightly augmented, although the figures obtained are below the average for market sugar.

SACCHAROSE AND REDUCING SUGAR CONTENTS OF SERIES A, CALCULATED TO A DRY MATTER BASIS

Treatment	Sample number	Saccharose	Reducing sugar
Control	2	95.41	0.97
Inoculated with organism XXXIII..	7	96.79	1.55
Inoculated with organism XXXVI...	8	96.73	2.09
Inoculated with organism L........	9	96.54	1.56
Inoculated with organism LIII......	10	97.16	1.44
Inoculated with organism LVI......	11	96.16	1.64
Inoculated with organism 5.........	12	97.14	1.15

SERIES B. MILKY SAP BACTERIA

Sap samples 13 and 14 were inoculated with organisms obtained from milky, "sour" sap, while No. 15 was inoculated with a culture obtained originally from stringy peas. The type of souring produced was characteristic and similar in all cases, except that the foreigner was capable of very slight acid production, accompanied by but little gas formation as indicated by tests in a Smith tube. The inoculated sap became cloudy within the first few hours and soon developed a milky appearance. No marked odor was detected, but the flavor was unpleasantly changed, a bitter but not acid taste developing.

The syrups of this series, while darker than the control (No. 2), were very much lighter than were those of series A. All were placed in the first class as regards color; yet notwithstanding this fact the samples all present an unattractive appearance, because of their muddy and viscous character. No. 13 in particular developed this property to a marked degree. While the sap just before concentration showed no signs of stringing, this syrup possessed sufficient viscosity to enable it to be readily drawn into strings several inches long. The cloudy appearance remained undiminished after three months of sedimentation, during which time the jar was not disturbed. The flavor of the entire series, moreover, was very seriously impaired, being so unlike the natural maple taste that one unfamiliar with the history of the syrups would be inclined to question their genuineness. Syrup 13 was rated as of second grade in flavor and the others as of third grade. Their reducing sugar contents were small save in 15. The relatively large amount present in this syrup is perhaps the result of the acid produced during incubation.

SACCHAROSE AND REDUCING SUGAR CONTENTS OF SERIES B, CALCULATED TO A DRY MATTER BASIS

Treatment	Sample number	Saccharose	Reducing sugar
Control	2	95.41	0.97
Inoculated with XXVI	13	95.61	0.78
Inoculated with XXX	14	95.86	0.77
Inoculated with I	15	95.71	2.23

SERIES C. STRINGY SAP BACTERIA

Within a few hours after the introduction of a 70 c.c. culture of this organism into the sap, the material became cloudy and then milky. As the incubation proceeded a deep milky white color developed, which rendered even thin layers opaque. It became viscous and ropy, so that in turning it from one vessel to another the weight of the stream continued to syphon the sap over the edge of the dish even when the rim was raised to somewhat above the level of the liquid contained therein. It developed the characteristic sour, disagreeable, yeasty odor of the ropy sap from which the organism was obtained. The taste became bitter and unpleasant in the extreme. Fermentation tube tests showed moderate gas production, 15 to 25 percent of the closed arm being filled during the period of incubation, the gases produced being carbon dioxid and hydrogen. Titration tests before concentration of the sample showed that acid production was in progress, 50 c.c. of the sample requiring 85 c.c. of N/100 sodium hydroxid to neutralize it against phenolphthalein without heating. An equal quantity of the control sap was neutralized by 1 c.c. of the same alkali. The vapor evolved during the concentration was extremely unpleasant, and was sufficiently noticeable to attract the attention of a sugarmaker who was passing the house where the field laboratory was established. Although he was entirely unaware of the nature of the experiments, the steam borne to him through an open window elicited the remark, "It smells like the last of sugaring." The syrup obtained was similar in color to that obtained in series B., being light colored but muddy in appearance. After standing upon the laboratory shelves for four months the muddy character was still very marked, showing that it was not easily removed by sedimentation. While rated as of first grade in color it was easily third class in flavor.

SACCHAROSE AND REDUCING SUGAR CONTENTS OF SERIES C, CALCULATED TO A DRY MATTER BASIS

Treatment	Sample number	Saccharose	Reducing sugar
Control	1	95.41	0.97
Inoculated with LXXXVII	16	96.12	1.72

SERIES D. YEASTS AND MOLDS

The inoculation experiments with yeasts and molds, conducted on samples 17-23 inclusive, were less satisfactory than were those with other organisms, because of the relatively high initial contamination of the sap employed. As previously noted, the sap was drawn several days later than that used in the first series. At the close of the incubation period the control was beginning to show signs of change from the continued growth of the organisms naturally present. An examination of the slime produced on the sides and bottom of the buckets of the inoculated sap showed the presence of great numbers of bacteria and comparatively few of the specific yeasts or molds introduced. Moreover, the type of souring produced was very similar to that described for series A and B. Tests for acid formation and gas production gave negative results, which were later confirmed in pure culture experiments. Observations confined to an examination of the sap during the incubation period would have led to the conclusion that the yeasts and molds employed developed too slowly in the maple sap to be of importance. On the other hand the bacteria appeared to develop better in the samples inoculated with yeasts than in the control. This cannot be due to food matter introduced with the inoculation material, since an equal quantity of sterile medium of the same composition was added to the control. It is possible that some stimulating relation exists between these organisms and the bacteria. If this should prove to be the case, it will follow that the yeast and molds are important factors in the spoiling of sap, because of the impetus they give to bacterial development, as well as because of any changes which may be induced by their own metabolism. Upon concentrating the materials, however, a surprising difference was noted between the control (No. 5) and the other samples of the series. This difference can be accounted for only by the artificial inoculation. The control, while dark in color and of a less delicate flavor than the control of the first three series, was yet a good product, justly scored as first grade. Numbers 17, 20 and 21 of the inoculated samples were rated as first grade in color, the other four as second grade. In flavor, numbers 19 and 23 were rated as third grade while the remaining five were scored as of second grade. No. 19 was regarded with another of an earlier series as the poorest samples produced during the season. The most significant fact brought out by the chemical analyses is the increase in reducing sugars caused by the introduced organisms.

SACCHAROSE AND REDUCING SUGAR CONTENTS OF SERIES D, CALCULATED TO A DRY MATTER BASIS

Treatment	Sample number	Saccharose	Reducing sugar
Control	5	95.37	1.58
Inoculated with 24	17	93.34	2.53
Inoculated with 25	18	95.30	3.01
Inoculated with LXIV	19	95.73	2.61
Inoculated with LXII	20	93.26	2.98
Inoculated with LXXV	21	92.76	3.47
Inoculated with LXXIX	22	91.65	3.12
Inoculated with all of above six organisms	23	93.28	4.09

LATE RUN SYRUP

The inoculation experiments as well as the laboratory and field studies showed clearly that bacteria are associated with poor quality in maple sap, and that anything which tends to favor the growth of these organisms is detrimental to the sugarmakers' product. It remained to determine whether the darker color and ill flavor of the late run syrup is to be attributed wholly or only in part to the activities of micro-organisms.

On April 12 it was noticed that the sap outputs of two trees were beginning to show signs of souring, notwithstanding the fact that care had been taken to empty the buckets at least once a day. In order to determine whether this sour condition was due to the development of the micro-organisms in the spouts and buckets, or whether it was to be attributed, in a measure at least, to sap changes within the trunk, both of these trees were retapped a second time on a level with the old hole and about five inches from it. New spouts and clean buckets were hung at the new tap holes. This was done at about 5 p. m. The sap was emptied from the old buckets, which were not washed, but were returned to their original places and left until noon the next day. The two lots of sap, the older and the fresher, each treated as a unit, were then transferred to the field laboratory in clean pails and examined at once as to appearance and flavor. The sap gathered from the old tap holes was slightly cloudy, of a yellowish cast and possessed a decidedly "buddy," bitter taste. The sap obtained from the same trees at the same time but from the new tap holes was perfectly clear and possessed no unpleasant taste. It was apparently entirely normal in every respect. These saps were made up into syrup at once. That from the old tap holes (No. 24) was muddy and off color, although not so poor as much of the material obtained by inoculation early in the season. While it was scored as first grade in color it was just on the border line between first and second grade. It was rated second grade in flavor. The syrup made from the new tap hole

(No. 6) was of very light color and excellent in flavor, being scored as first grade.

On the evening of April 13, sap was gathered again from the trees above described and that drawn from the newer tap holes combined with that obtained from two other trees which had been retapped earlier in the day. In order to determine the effect of a short period of storage, the material was left over night in new tin buckets which had been thoroughly scalded just before use. The sap from the old tap hole by this time had become badly clouded and had a marked bitter taste, while that from the new tap holes showed neither clouding nor change of flavor. The syrup from the old tap holes (No. 26) had the color of poor molasses with a flavor to match, being scored as third grade in color and a poor second grade in flavor. It was characterized as entirely lacking in maple flavor. The syrup from the new tap hole (No. 3) was of light amber color and good flavor, being rated as a good first grade article.

On April 16, three trees which had been running green sap were retapped in the same manner as just described. The tappings were made in the early morning just as sap was starting. Late in the afternoon of the same day the saps for both old and new tap holes were collected and transferred to the field laboratory where they remained over night at a temperature just below 32° F., as evidenced by the thin ice skim which formed. The following morning the two batches were made into syrup. That from the old tap hole (No. 25) was of dark color and of a decidedly "buddy" flavor, but scored a second grade in both respects. The syrup obtained from the new tap hole (No. 4) was of light color and of very good flavor, being one of the best samples produced during the season. While the flavor was very slightly inferior to that of the control of the first run, the color was fully as light, and it would easily pass for a gilt edge product.

SACCHAROSE AND REDUCING SUGAR CONTENTS OF SYRUPS MADE FROM LATE RUN SAPS, CALCULATED TO A DRY MATTER BASIS

Treatment	Sample number	Saccharose	Reducing sugar
Control, first run	2	95.41	0.97
New sap kept	3	96.02	0.61
New sap	4	96.42	0.51
New sap	6	95.19	0.82
Sour sap	24	95.27	2.76
Sour sap	25	95.05	3.13
Sour sap kept	26	92.56	3.55

SUMMARY OF ANALYTICAL RESULTS

For the sake of convenience in making comparisons the following summary of analytical results is given. The ratio column contains the results obtained by dividing the saccharose content by the reducing sugars, and is intended to show the ratio of the two. The higher the number, the lower the ratio of reducing sugar to saccharose. The samples included in this table have all been previously described except No. 1. Sample No. 1 belonged to the same batch of sap and was handled in exactly the same way as was sample No. 2, except that it was condensed to a syrup under conditions that required six hours for its evaporation. There was practically no difference in the flavor of the two samples, but the slowly evaporated material was slightly darker in color, a result presumably due to some chemical change which took place during the boiling. Attention has been called to the fact that the remaining 25 samples were concentrated under as nearly uniform conditions as could be obtained, so that the time required for evaporation did not in any case vary more than 10 or 15 minutes from an hour and one-half.

Description of sample	Sample number	Saccharose	Reducing sugar	Ratio	Color	Flavor	
Controls........	1	96.84	1.07%	90	1	1	
	2	95.41	0.97	98	1	1	cf. with A, B, C
	3	96.02	0.61	157	1	1	cf. with 26
	4	96.42	0.51	189	1	1	cf. with 25
	5	95.37	1.58	60	1	1	cf. with D
	6	95.19	0.82	116	1	1	cf. with 24.
Series A........	7	96.79	1.55	62	2	3	cf. with No. 2
	8	96.73	2.09	46	2	2	
	9	96.54	1.56	62	2	2	
	10	97.16	1.44	67	1	2	
	11	96.16	1.64	59	2	2	
	12	97.14	1.15	84	2	2	
Series B........	13	95.61	0.78	122	1	2	
	14	95.86	0.77	124	1	3	
	15	95.71	2.23	43	1	3	
Series C........ ..	16	96.12	1.72	56	1	3	
Series D......	17	93.34	2.53	37	1	2	cf. with No. 5
	18	95.30	3.01	32	2	2	
	19	95.73	2.61	37	2	3	
	20	93.26	2.98	31	1	2	
	21	92.76	3.47	27	1	2	
	22	91.65	3.12	29	2	2	
	23	93.28	4.09	23	2	3	
Old tap hole...	24	95.27	2.76	35	1	2	cf. with 6
	25	94.05	3.13	30	2	2	cf. with 4
	26	92.56	3.55	26	3	2	cf. with 3

CONCLUSIONS

A consideration of the data reviewed in the previous pages and of the discussion thereof would seem to justify the following preliminary conclusions.

While maple sap within the vascular bundles of the tree is free from bacteria, yeast, and molds, it becomes infected therewith in the tap holes, spouts, and buckets. These micro-organisms are important factors operating against successful sugar making. There are specific types of poor sap which are caused by specific organisms. There are other types of poor sap which may be produced either by the independent action of individual species, or by the collective action of a large group of the common saprophytic organisms. The common green sap is to be attributed to the action of green fluorescent bacteria, rather than to the swelling of the buds. The term "buddy" as applied to it is a misnomer. Such material might be described more accurately, though perhaps less elegantly, as "buggy." The dark color of syrup made from late run sap, which has been protected from the entrance of extraneous materials, is due entirely to the action of micro-organisms. The buddy flavor is likewise due in a large measure to the same cause. In the opinion of the author the very slight difference in flavor between the sample produced from the fresh tap hole during the last run, and the sample produced from the fresh tap hole during the first run, could easily be accounted for by the action of micro-organisms growing in the sap during the few hours while it was being collected. The much warmer temperature would certainly result in a very much more rapid development of organisms in the sap drawn on April 16 than in that drawn late in March. However, it is possible that some slight change in the composition of the sap itself may take place within the tree, and final judgment upon this point must await the results of further studies which will be carried out as opportunity permits. In any event, it is an established fact that the warmer weather of the last days of the sugar season affords conditions which are especially favorable to the rapid multiplication of those organisms which have become established in the spouts and buckets. Under ordinary conditions late in the season, they are present in the sap in enormous numbers and result in the production of a very dark type of maple syrup which is also of inferior flavor. By eliminating their action the development of the dark color can be prevented, and nearly all, if not all, of the buddy flavor can be avoided.

REMEDIAL MEASURES

Practical remedial measures must be based upon efforts to minimize the contamination with micro-organisms and to restrict the period of their action to the shortest possible time. The lower their content and the shorter their period of growth, the better the product. As in dairying, cleanliness must be the watchword of the producer of superior goods. Clean spouts, clean covered buckets, and clean holders are necessities. The use of metal utensils is to be preferred to the employment of wooden ones, because the latter material affords organic matter upon which organisms may develop. Wooden utensils are moreover less readily cleaned. Covered buckets are preferable to open ones, because they not only keep out rain and snow, but they prevent the entrance of bits of falling bark, decayed wood, and other inert matter. Such material is always heavily charged with bacteria and other organisms; so that in addition to the coloring matter carried in the refuse itself, agents are introduced which further discolor the product through their vital activities. In the Ohio valley, where the sugar season is somewhat longer than is the case in Vermont, the practice of retapping is much in favor. The trees are first tapped with a small bit, then after the season becomes more advanced, the holes are rimmed out with the usual size rimmer. This not only reopens the wound which has become partially dried out, but also frees it from much of the accumulated growth of micro-organisms. The practice of gathering the buckets and washing them at intervals is recommended by certain producers who are interested in turning out only a gilt edge product. This is more easily done if extra buckets are available so that clean ones may be hung at the spouts at the same time the old infected ones are gathered. Buckets in different parts of the orchard may thus be changed on different days. The time between runs affords a favorable opportunity for the work of washing. Flushing out the tap holes and spouts with clean water would doubtless aid in the efficiency of the treatment. Whether the increase in the market value of the syrup produced in this way will be sufficient to justify the additional labor and expense involved is a question which must be considered by the sugar maker, and decided by him according to local conditions and individual tastes.

The practice of storing sap is one to be avoided whenever possible. Modern evaporators not only make long periods of boiling unnecessary, but they make it possible to concentrate the runs day by day as they occur. These are doubtless two important factors contributing to the improved quality of evaporator syrup as compared with that produced by older methods. When storing is resorted to, the temperature of the tank should be kept as low as possible, because the lower the temperature the slower the micro-organisms develop. Holders should be located without rather than within the boiling house, where the heat of the pans will not influence their temperature.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN No. 152
(In part a revision of bulletin 81)

APRIL, 1910

Commercial Feeding Stuffs
Principles and Practice of Stock Feeding

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*In cooperation with Bu. An. Ind. U. S. Dept. Agr.

BULLETIN 152: COMMERCIAL FEEDING STUFFS
PRINCIPLES AND PRACTICE OF STOCK FEEDING

By J. L. Hills, C. H. Jones and P. A. Benedict

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SUMMARY

As to the Winter and Spring Inspections of 1909-10

The sampling agents drew samples representing 313 brands of goods, a few of which were slightly deficient. A deficiency in cottonseed feed meal was by the voluntary act of the jobber made good to the local dealer and by the latter to the individual purchasers. Distillers' dried grains and gluten feeds, goods which in the past as a class have been apt to fail, were found this year up to par. As a whole the results of the two inspections were better than has been found in years.—Pages 521-537.

SUMMARY

As to the Principles and Practice of Stock Feeding

Animal nutrition. The animal body is made up of water, ash, protein and fat; while vegetable matter is composed of the same ingredients, together with crude or woody fiber, and nitrogen-free extract (starch, sugars, gums, etc.) The latter two (crude fiber and nitrogen-free extract) are collectively termed carbohydrates. Protein, carbohydrates and fat are the main nutrients to be considered in compounding rations.

The main function of protein is to form flesh and kindred materials. It may under some circumstances form fat, produce heat and furnish material for energy production. It seems to be a milk stimulant. The functions of the carbohydrates and fat are to produce heat, muscular energy, body, and, apparently, milk fat, and to protect protein from overconsumption.

The digestibility of food is variously affected by sundry conditions of the animal and its feed. The several nutrients are assimilated in quite different proportions when in different combinations. The determination of these proportions is the aim of digestion experiments.—Pages 537-557.

Feeding standards. These are of three sorts, the physiological, the practicable and the average standards. The first are not absolute rules but average estimates based on the present knowledge of the physiological needs of farm stock. They consider maximum yield only. The second are variables, take cognizance of costs of raw material and of product, and are the result of the experience, observation and study of the individual feeder. The third are simply the expression of average feeding practice, apart from considerations of adaptation or profit.

The standards are many in number and have been proposed by sundry German and American investigators. They are useful as guides rather than as rules. Any standard is better than none. Choice will vary in accordance with sundry considerations. They may be made use of in calculating a ration or in planning a season's feeding campaign. Examples of ration calculation and season planning are given at length.—Pages 557-582.

Sundry economic considerations. A classification of the more common roughages and concentrates aids in indicating their values in ration making. In making sales and purchases the main point to bear in mind is to sell so far as practicable carbon, hydrogen and oxygen, air-given elements, and to buy nitrogen, phosphoric acid and potash, soil-derived ingredients readily lost through cropping. A second point, hardly less important, is to make one's farm primarily a carbohydrate factory and to seek at the feed store such supplementary protein as may not be economically home grown. —Pages 582-590.

A glossary of definitions of the technical terms used is given, as well as tables showing the sundry standards, the composition and digestible ingredients of the several fodders and feeds fed in New England, and a convenience table which simplifies the mathematics of calculating a ration; and, finally, the entire bulletin is well indexed.—Pages 590-616.

II. INTRODUCTION

It is a settled policy at this Station yearly to feature some special topic in its annual fertilizer bulletin. Inasmuch as the statutes provide for the publication of "information in relation to the character, composition, value and use of fertilizers," it has been customary for years to furnish such information. It has thus been possible during the past seven years to purvey much matter bearing directly upon soils and soil management and particularly upon the fertilization of the soil. The funds furnished by the license fees and, later, by the passage of the state printing law have permitted during this time a somewhat more free use of printers' ink for this educational purpose than in previous years.

The statutes are equally broad as regards the purveyal of matter relating to feeding stuffs, for the section reads: "The results of analyses * * * * * * * * together with additional information in relation to the character, composition, value and use of such fertilizers or feeding stuffs as circumstances may advise, shall be published in reports, bulletins, special circulars or elsewhere as often as deemed advisable." Prior to the decision of the Attorney General to the effect that the state printing law embraced within its purview the publication of the station bulletins, it was impossible, owing to the extremely small appropriation for feeding stuff inspection ($500 yearly), to print more than the bare analyses, together with the briefest of comments; but now it is expected to issue informational bulletins as to the use of feeding stuffs, in much the same manner as has been done in the past in connection with the publication of commercial fertilizer analyses. Thus, for instance, bulletin 144 reviewed at length the nature and manufacture of the various feeding stuffs offered upon Vermont markets, such as cottonseed and linseed meals, gluten feeds, flax feeds, molasses feeds, corn and oat feeds, the various wheat offals, alfalfa meals, and poultry feeds. It discussed the economics of feed purchase and the relative cost of various types of feeds. It outlined the principles underlying the formulation of rations and printed some two dozen or more. It explained the chemical composition of feeds and the relative services of roughages and concentrates in feeding practise, and had a little to say touching home grown protein. Furthermore, the service which a feeding stuff inspection may do for the farmers was developed as a means of detecting adulteration, of disclosing misleading brand names, of securing the maintenance of guaranties, of ensuring the grade of goods sold, of enabling a more certain comparison between feeds and between the cost of feeds, and of assisting one in an effort to compound a ration.

In the current issue it is intended to take up matters dealing in a broad way with the principles and practise of stock feeding; and it is expected in future issues to cover more or less completely the various phases of this general subject. If this policy is pursued consistently, the recipient of the station bulletins, if he keeps them, should, in the course of time, possess quite a compendium of information upon this special subject.

Bulletin 81, issued 10 years ago, deals with and is entitled the "Principles and Practice of Stock Feeding." This was a somewhat popular bulletin. Doubtless in part because of its popularity, it has been nearly out of print for many years. There is still a considerable call for published matter dealing with stock feeding. So it has seemed worth while to revamp this ten-year-old; revising here, re-writing there, retracting some statements now not germane, reiterating others which the passage of time has served to emphasize, re-enforcing the argument wherever such action seemed desirable. Devoid of the results of original research, purely a matter of compilation, as was its predecessor, the bulletin is issued, as has already been remarked, under the shelter of the feeding stuffs inspection appropriation and the statutes dealing with state printing, thus not entrenching directly or indirectly upon the national funds, the expenditure of which is confined to research and to the publication of the results attained by such investigations.

The writer has tried to state matters clearly and so far as possible to refrain from the use of technical terms. Such as are used are defined. (See pages 539 to 541, also glossary, 591-597). At times it has been impossible to avoid the use of technical terms for which there are no popular synonyms. The reader is reminded, however, that the natural laws underlying stock feeding and man's experience therein are not kindergarten subjects, but that careful study is needed if their mastery is sought. No excuse is offered for the prominence given to dairying. Examples and illustrations are all taken from dairying practice. To cover all the branches of stock feeding would be to write a book.

III. RESULTS OF INSPECTION

The sampling agents of the Station visited 59 towns and villages in Vermont in December, 1909, and March, 1910, and drew 465 samples from dealers' stocks, representing 313 brands of goods either subject to or exempt from the necessity of guaranty. These samples have been examined chemically for protein. Both guarantied and unguarantied goods were examined, the former to determine so far as might be their purity as well as the maintenance of the standards fixed by their makers; the latter to determine, if possible, whether as a matter of fact the goods were pure and not subject to guaranty.

The inspections were among the most satisfactory of the eleven years since the law went into effect, but few shortages occurring and these not serious ones.

The reader who may be interested in the economics of feed purchase is referred to matter on pages 34 to 44 of bulletin 144, as well as to that on pages 582-590 of the present issue. Full descriptions of the nature and manufacture of the sundry goods offered on Vermont markets will be found on pages 22 to 34 of bulletin 144, together with a discussion of the advisability or inadvisability of their purchase.

I. ANALYSES

INSPECTION OF THE WINTER OF 1909-10

COTTONSEED MEAL

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	38.5	39.4
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	41.	40.1
F. W. Brodé Co., Memphis, Tenn.	Owl	41.	41.6
J. Lindsey Wells, Memphis, Tenn.	Star	41.	40.1
Buckeye Cotton Oil Co., Cincinnati, O.	Buckeye Prime	39.	37.9
American Cotton Oil Co., Huntsville, Ala.	Choice	41.	42.3
Hunter Bros. Milling Co., St. Louis, Mo.	Prime	41.	39.7
Hunter Bros. Milling Co., St. Louis, Mo.	Prime	38.5	38.8
J. E. Soper & Co., Boston, Mass.	Prime	38.5	38.6
Tennessee Cotton Oil Co.	Prime	41.	40.8
Imperial Cotton Oil Co., Dawson Ga.		...	39.2

COTTONSEED FEED MEAL

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Humphreys, Godwin & Co., Memphis, Tenn.	77 Feed Meal	22.	18.2

LINSEED MEAL

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
American Linseed Co., New York, N. Y.	Old Process	32.	37.1
American Linseed Co., Chicago, Ill.	Old Process	36.	37.3
Midland Linseed Co., Chicago, Ill.	Old Process	32.	37.3
Kellogg & Miller, Amsterdam, N. Y.	Old Process	33.	35.3
		...	35.9

GROUND FLAX FLAKES

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
C. R. Lull Co., Milwaukee, Wis.	Gr. Flax Flakes	17.4	17.3

DISTILLERS' DRIED GRAINS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Ajax Milling Co., Buffalo, N. Y.	Ajax Flakes	31.	31.6
Dewey Bros. Co., Blanchester, O.	Dewey's	30.	28.2

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Deutsch & Sickert Co., Milwaukee, Wis.	Climax Grains	34.	31.8
J. W. Biles Co., Cincinnati, O.	XXXX	31.	30.7
J. D. Page & Co., Syracuse, N. Y.	Empire State Dairy Feed	27.2	30.2
Hottelet & Co., Milwaukee, Wis.	Bourbon Grains	31.	30.
PROPRIETARY FEEDS			
St. Albans Grain Co., St. Albans, Vt.	Paragon Dairy	28.	29.9
Ajax Milling Co., Buffalo, N. Y.	Unicorn Dairy Ration	26.	27.9
J. W. Biles Co., Cincinnati, O.	Union Grains	24.	25.4
J. W. Biles Co., Cincinnati, O.	Ubiko Horse	16.	19.2
H. E. Shaw, Stowe Vt.	Shaw's Mixture	...	19.5
L. A. Averill, Barre, Vt.	Averill's Dairy Feed	...	22.7
GLUTEN FEEDS			
Douglass & Co., Cedar Rapids, Iowa	Cedar Rapids	22.	23.7
Corn Products Refining Co., New York, N. Y.	Buffalo	24.	26.9
Corn Products Refining Co., New York, N. Y.	Buffalo	23.	24.3
Corn Products Refining Co., New York, N. Y.	Buffalo	24.	28.
Clinton Sugar Refining Co., Clinton, Iowa	Clinton	20.	22.8
American Maize Products Co., New York, N. Y.	Cream of Corn	23.	26.8
MOLASSES FEEDS			
American Milling Co., Chicago, Ill.	Sucrene Dairy	16.5	18.
Sugarine Co.	Sugarine Dairy	16.5	17.3
Northwest Mill Co., Winona, Minn.	Sugarota Dairy	18.	15.4
Northwest Mill Co., Winona, Minn.	Sugarota Dairy	16.	16.
Great Western Cereal Co., Chicago, Ill.	Daisy Dairy	15.	16.
Great Western Cereal Co., Chicago, Ill.	Daisy Dairy	14.	13.5
Husted Milling Co., Buffalo, N. Y.	Husted	18.	20.8
Chas. A. Krause, Milwaukee, Wis.	Badger Dairy	16.	19.8
Quaker Oats Co., Chicago, Ill.	Quaker Dairy	16.	17.8

OAT FEEDS, CORN AND OAT FEEDS, ETC.

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Quaker Oats Co., Chicago, Ill.	Schumaker's Stock	10.	10.9
Great Western Cereal Co., Chicago, Ill.	Sterling Stock	10.	10.5
C. M. Cox Co., Boston, Mass.	Wirthmore Stock	9.	10.5
A. H. McLeod Milling Co., St. Johnsbury, Vt.	Brooks' Fancy Stock	7.6	7.7
Quaker Oats Co., Chicago, Ill.	Victor	7.5	7.9
Quaker Oats Co., Chicago, Ill.	Victor	7.5	8.4
Husted Milling Co., Buffalo, N. Y.	Mayflower Stock	7.5	9.4
Griswold & McKinnon, St. Johnsbury, Vt.	Special	7.6	8.2
E. W. Bailey & Co., Montpelier, Vt.	C. & O. Stock	...	9.6
Buffalo Cereal Co., Buffalo, N. Y.	C. & O.	9.	10.5
Commercial Milling Co., Detroit, Mich.	Waumbeck Stable	9.7	9.5
Commercial Milling Co., Detroit, Mich.	Henkels' Chop	8.	9.6
HOMINY FEED			
Myrtle Milling Co., Sioux City, Iowa		12.	11.4
American Hominy Co., Indianapolis, Ind.	Homco	8.5	11.8
WHEAT OFFALS			
MIXED FEED			
Acme Evans Co., Indianapolis, Ind.	Acme	15.	18.4
Alma Roller Mills Co., Alma, Mich.	Bran and Middlings	16.1	16.9
Ashley & Blanchard, Windsor, Vt.	Fancy	16.	18.5
Amendt Milling Co.	Amco	...	17.6
Ansted & Burke Co., Springfield, Ohio	ABC	14.	17.1
E. W. Bailey & Co., Montpelier, Vt.	Fancy Winter	...	16.9
Bowker Milling Co., Minneapolis, Minn.	White Satin	16.	18.8
W. A. Coombs & Co., Coldwater, Mich.	Rob Roy	15.	16.4
E. Crosby & Co., Brattleboro, Vt.	M F	...	17.1
Detroit Milling Co., Detroit, Mich.	Adrian Pure Winter Wh't.	17.5	16.6

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Duluth Milling Co., Duluth, Minn.	Boston	16.	18.
Everett Aughenbaugh & Co., Waseca, Minn.	Eaco	15.	17.3
Griswold & McKinnon, St. Johnsbury, Vt.	Adams' Fancy	...	18.1
Griswold & McKinnon, St. Johnsbury, Vt.	Xtra Good	...	18.2
Hunter Bros. Milling Co., St. Louis, Mo.	Hunter's Matchless	15.	18.6
Hennepin Milling Co., Minneapolis, Minn.	Ben Hur	16.	18.4
A. H. McLeod Milling Co., St. Johnsbury, Vt.	Brook's Fancy	16.	16.4
A. B. McCrillis & Son, Boston, Mass.	Xtra Powerful	16.	19.1
R. P. Moore Milling Co., Princeton, Ind.	King Feed	16.4	18.6
National Milling Co., Toledo, Ohio	Pennant	...	17.1
Portland Milling Co., Portland, Me.	Champion	...	17.1
Pillsbury's Mills, Minneapolis, Minn.	Pillsbury Fancy	16.	17.8
Pillsbury's Mills, Minneapolis, Minn.	Pillsbury Fancy	16.	18.4
Russell Miller Milling Co., Minneapolis, Minn.	Occident	16.	18.9
Russell Miller Milling Co., Minneapolis, Minn.	Occident	15.	19.3
Stratton & Co., Concord, N. H.		...	16.7
David Stott, Detroit, Mich.	Stott's Honest	...	16.9
St. Albans Grain Co., St. Albans, Vt.	Hygrade	...	18.5
Sheffield King Milling Co., Minneapolis, Minn.	Gold Mine	17.	18.2
Geo. Tillotson Milling Co., St. Cloud, Minn.	Waumbeck	15.	17.3
Valley City Milling Co., Grand Rapids, Mich.	Vinco	15.2	16.7
Williams Bros. Co., Kent, Ohio	Kent	12.	17.1
Waggoner Gates Milling Co., Independence, Mo.		15.	17.8
Waggoner Gates Milling Co., Independence, Mo.		...	16.7
Williams Bros. Co., Kent, Ohio	Kent's Winter Wheat	12-19.5	17.2
Williams Bros. Co., Kent, Ohio	Kent's Winter Wheat	12-19.	17.
Henry Jennings, Boston, Mass.	Dairy Winter	11.	12.9

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Valley City Milling Co., Grand Rapids, Mich.	Vinco Cow Feed	...	15.8
Northwestern Consolidated Milling Co., Minneapolis, Minn.	XXX Comet Pure	17.	19.9
C. M. Cox Co., Boston, Mass.	Wirthmore	16.	18.
F. W. Stock & Son, Hillsdale, Mich.	Superior	...	16.3
F. W. Stock & Son, Hillsdale, Mich.	Monarch	...	17.3
Lexington Roller Mills, Lexington, Ky.	Pure Feed	...	16.7
Blanton Milling Co., Indianapolis, Ind.	Blanton	15.	18.9
Russell Flour Co., Albany, N. Y.	Regular	15.	18.4
Lexington Roller Mills Co., Lexington, Ky.	Pure	...	16.9
Eldred Milling Co., Jackson, Mich.	Pure	16.3	16.4
Acme Evans Co., Indianapolis, Ind.	Hoosier	15.	18.9
Hunter Bros. Milling Co., St. Louis, Mo.	Sunshine	15.	18.

WHEAT MIDDLINGS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Wm. A. Coombs Milling Co., Coldwater, Mich.	White	...	16.3
Wm. A. Coombs Milling Co., Coldwater, Mich.	Fancy White	15.	16.9
H. C. Cole Milling Co., Chester, Ill.		16.	18.6
Crosby Roller Milling Co., Topeka, Kansas	Pure Winter Wheat	16.	18.9
Detroit Milling Co., Detroit, Mich.	Apex	17.	17.8
Duluth Superior Milling Co., Duluth, Minn.	White	16.8	18.4
Duluth Superior Milling Co., Duluth, Minn.	S Wheat	16.3	18.9
Jas. Quick Milling Co., Montgomery, Minn.	Standard	17.3	18.6
Hunter Bros. Milling Co., St. Louis, Mo.	Winter Wheat	16.	20.4
Hunter, Robinson, Wing Milling Co., St. Louis, Mo.	Interstate	14.5	19.5
Hennepin Milling Co., Minneapolis, Minn.	Ben Hur Flour	17.	20.4
J. F. Jenks Milling Co., St. Louis, Mo., and Belleville, Ill.	Choom	15.	16.9
Marshall Milling Co.	Shorts	17.	18.4
National Milling Co., Toledo, Ohio	Pure Wheat	...	19.3

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
National Milling Co., Toledo, Ohio	Pure Winter Wheat	...	18.4
North Western Consolidated Milling Co. Minneapolis, Minn.	Pure Wheat	15.8	18.6
Pillsbury's Mills, Minneapolis, Minn.	B	13.	16.9
Pillsbury's Mills, Minneapolis, Minn.	A	15.	19.1
Pillsbury's Mills, Minneapolis, Minn.	B	15.	18.6
Pillsbury's Mills, Minneapolis, Minn.	XX Daisy	16.	18.9
David Stott, Detroit, Mich.	Pennant	17.	18.4
Valley City Milling Co., Grand Rapids, Mich.	Vinco	15.3	16.3
Valley City Milling Co., Grand Rapids, Mich.	Choice Vinco	15.8	16.4
Washburn, Crosby Co., Minneapolis, Minn.	Unadulterated Flour	17.	18.9
Washburn, Crosby Co., Minneapolis, Minn.	Standard	15.	18.9
Washburn, Crosby Co., Minneapolis, Minn.	Standard	15.	18.9
	Wirthmore	15.	19.3
	Spring	...	18.4
		...	17.6
G. G. Betts, Minneapolis, Minn.		...	15.8
Alma Roller Mills, Alma, Mich.	Bran and Middlings	...	15.4

WHEAT BRAN

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Amendt Milling Co.	Amco	14.	16.7
Berger Chittenden Milling Co., Milwaukee, Wis.	Badger	15.	16.9
Bill, Bell & Co., Ogdensburg, N. Y.	Choice	...	17.3
Barber Milling Co., Minneapolis, Minn.	Bran Flakes	13.	18.6
Big Diamond Milling Co., Minneapolis, Minn.	Big Diamond	12.8	16.
Big Diamond Milling Co., Minneapolis, Minn.	Big Diamond	12.8	14.7
Geo. C. Christian Co., Minneapolis, Minn.		15.	16.
E. Crosby & Co., Brattleboro, Vt.	Pure Winter Wheat	14.	17.3
Gardner Mills, Hastings, Minn.	Clover Leaf	13.5	16.7
Hennepin Mill Co., Minneapolis, Minn.	Ben Hur, Coarse	14.5	17.6
Kemper Milling & Elevator Co., Kansas City, Mo.	Diamond	14.6	17.1

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Kemper Milling & Elevator Co., Kansas City, Mo.	Anchor	14.5	17.6
Pillsbury's Mills, Minneapolis, Minn.	Pure Wheat	14.5	15.4
Northwestern Milling Co., Little Falls, Minn.	Pure	14.3	16.9
New Prague Flouring Mill Co., New Prague, Minn.	Seal of Minn.	14.	15.8
National Milling Co., Toledo, Ohio	Pennant	...	16.4
National Milling Co., Toledo, Ohio	Pennant	...	16.9
Sleepy Eye Milling Co., Sleepy Eye, Minn.	Pure	15.1	17.3
Sleepy Eye Milling Co., Sleepy Eye, Minn.	Pure	16.	17.3
Sleepy Eye Milling Co., Sleepy Eye, Minn.	Choice Low Grade	15.3	18.2
Sleepy Eye Milling Co., Sleepy Eye, Minn.	Low Grade	15.3	17.6
Sleepy Eye Milling Co., Sleepy Eye, Minn.		15.1	16.4
Star & Crescent Milling Co.	Star and Crescent	15.	16.4
Geo. Tillotson Milling Co., St. Cloud, Minn.	Fancy	14.	16.
Thompson Milling Co., Lockport, N. Y.		...	17.1
Washburn, Crosby Co., Buffalo, N. Y.	Coarse	14.5	16.7
E. S. Woodworth Co., Minneapolis, Minn.	Snow's Flaky	14.3	15.4
	M	...	17.8

PROVENDERS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
L. A. Averill, Barre, Vt.		...	10.8
Frank Adams & Co., Bellows Falls, Vt.		...	10.5
Burditt Bros., Rutland, Vt.		...	10.3
H. M. Brown & Co., Castleton, Vt.		...	9.9
A. Batchelder, Plainfield, Vt.		...	10.1
Davis Feed Co., Rutland, Vt.		...	10.1
H. W. Putnam, Bennington, Vt.		...	9.6
A. G. Spaulding, Ludlow, Vt.		...	10.5
C. S. Thwing, Putney, Vt.		...	10.3
A. W. Washburn, Bethel, Vt.		...	10.1
Waterman Bros., Chester Depot, Vt.		...	9.6
W. S. Ware & Co., Chester, Vt.		...	10.5
W. R. White, No. Bennington, Vt.		...	9.4

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
W. H. Stearns, Johnson, Vt.		...	9.9
E. W. Bailey & Co., Swanton, Vt.		...	9.6
RED DOG (FEEDING) FLOUR			
L. Christian & Co., Minneapolis, Minn.	Red Dog	15.4	16.7
Hennepin Mill Co., Minneapolis, Minn.	Ben Hur Red Dog	17.	19.5
Hennepin Mill Co., Minneapolis, Minn.	Ben Hur Red Dog	17.	20.8
MISCELLANEOUS—CORN MEALS AND CORN PRODUCTS			
	Germaline	9.	9.2
Buffalo Cereal Co., Buffalo, N. Y.	Mohawk Corn Meal	...	8.3
Buffalo Cereal Co., Buffalo, N. Y.	Mohawk Corn Meal	...	8.2
Buffalo Cereal Co., Buffalo, N. Y.	Yellow B. Corn Meal	...	9.6
Geo. A. Taylor, Ogdensburg, N. Y.	A. A. Meal	...	7.8
Husted Milling Co., Buffalo, N. Y.	Meal	...	7.9
Toledo Elevator Co., Toledo, Ohio.	Star Feed	7.	8.8
RYE PRODUCTS			
Boutwell Mill & Grain Co., Troy, N. Y.	Rye Middlings	...	15.
Boutwell Mill & Grain Co., Troy, N. Y.	Rye Middlings	...	15.4
Washburn, Crosby & Co., Minneapolis, Minn.	Rye Middlings	...	16.9
M. G. Rankin Co., Milwaukee, Wis.	Rye Feed	...	15.1
MISCELLANEOUS			
Buffalo Cereal Co., Buffalo, N. Y.	Ground Oats	...	11.8
Ralston Purina Co., St. Louis, Mo.	Purina Feed	12.5	12.3
POULTRY FEED			
C. M. Cox Co., St. Albans, Vt.	Wirthmore Poultry Mash	20.	14.6

INSPECTION OF THE SPRING OF 1910

COTTONSEED MEAL

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Humphreys, Godwin & Co., Memphis, Tenn.	Dixie	38.5	41.6
F. W. Brodé Co., Memphis, Tenn.	Owl	41.	42.5
Buckeye Cotton Oil Co., Cincinnati, Ohio	Buckeye Prime	39.	40.8
American Cotton Oil Co., New York, N. Y.	Choice	41.	38.8
J. Lindsey Wells Co., Memphis, Tenn.	Star	41.	38.4
S. P. Davis, Little Rock, Ark.	Good Luck	41.	42.8
		...	43.4
C. C. Johnson & Co., Memphis, Tenn.	Prime	41.	41.5
Imperial Cotton Oil Mill Co., Memphis, Tenn.	Imperial	41.	38.8
COTTONSEED FEED MEAL			
Humphreys, Godwin & Co., Memphis, Tenn.	77 Feed Meal	22.	23.3
LINSEED MEAL			
American Linseed Oil Co., Chicago, Ill.	New Process	36.	38.1
American Linseed Oil Co., New York, N. Y.	Old Process	32.	36.8
DISTILLERS' DRIED GRAINS			
Ajax Milling Co., New York, N. Y.	Ajax Flakes	31.	31.6
J. W. Biles Co., Cincinnati, Ohio	XXXX	31.	32.3
J. W. Biles Co., Cincinnati, Ohio	XX	...	32.9
J. W. Biles Co., Cincinnati, Ohio	XX	27.	27.4
Hottelet & Co., Milwaukee, Wis.	Rector	30.	29.8
Hottelet & Co., Milwaukee, Wis.	Bourbon Grains	31.	30.1
J. W. Biles Co., Cincinnati, Ohio	Dearborn	22.	26.3
Deutsch & Sickert Co., Milwaukee, Wis.	Climax Grains	30.	33.1
Dewey Bros. Co., Blanchester, Ohio	Corn (3)	26.	28.3
J. D. Page & Co., Syracuse, N. Y.	Empire State Dairy Feed	27.2	28.1

PROPRIETARY FEEDS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Ajax Mill and Feed Co., Buffalo, N. Y.	Unicorn Dairy	26.	28.1
J. W. Biles Co., Cincinnati, Ohio	Union Grains	24.	25.
St. Albans Grain Co., St. Albans, Vt.	Paragon Dairy	28.	31.6
J. W. Biles Co., Cincinnati, Ohio	Ubiko Horse	16.	19.2

BREWERS' DRIED GRAINS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Anheuser-Busch Brewing Association, St. Louis, Mo.		24.	26.5
Hottelet & Co., Milwaukee, Wis.	Holstein	27.	28.5

GLUTEN FEED

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Corn Products Mfg. Co., Chicago, Ill.	Buffalo	24.	27.2
American Maize Products Co., New York, N. Y.	Cream of Corn	23.	24.6
Clinton Sugar Refining Co., Clinton, Iowa	Clinton	20.	22.8
Clinton Sugar Refining Co., Clinton, Iowa	Clinton	23.	24.6
Corn Products Co., New York, N. Y.	Globe	24.	26.9
Douglass & Co., Cedar Rapids, Iowa	Cedar Rapids	22.	24.1
Corn Products Co., New York, N. Y.	Crescent	24.	26.

MOLASSES FEEDS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Northwest Mill Co., Winona, Minn.	Sugarota	16.	14.7
American Milling Co., Chicago, Ill.	Sucrene	16.5	18.
International Sugar Feed Co., Indianapolis, Ind.	International Sugared	16.5	19.8
Quaker Oats Co., Chicago, Ill.	Quaker Dairy	16.	17.1

OAT FEEDS, CORN AND OAT FEEDS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Quaker Oats Co., Chicago, Ill.	Schumaker Stock	10.	11.6
Quaker Oats Co., Chicago, Ill.	Quaker Dairy	16.	18.2
Quaker Oats Co., Chicago, Ill.	Victor	7.5	9.6
Great Western Cereal Co., Chicago, Ill.	Sterling Stock	10.	10.9

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Griswold & McKinnon, St. Johnsbury, Vt.	Special Provender	7.6	7.7
Griswold & McKinnon, St. Johnsbury, Vt.	Extra Good Stock	7.6	8.3
A. H. McLeod Milling Co., St. Johnsbury, Vt.	Brooks' Fancy Stock	...	7.
Husted Milling Co., Buffalo, N. Y.	Mayflower Stock	7.5	8.8
Husted Milling Co., Buffalo, N. Y.	Monarch Chop	7.5	9.2
St. Albans Grain Co., St. Albans, Vt.	Wirthmore Stock	9.	9.9
HOMINY FEED			
Suffern, Hunt & Co., Decatur, Ill.	Acme	9.3	10.5
MISCELLANEOUS			
German-American Sugar Co., Bay City, Mich.	Dried Beet Pulp	8.	9.2
Blatchford Calf Meal Factory, Waukegan, Ill.	Blatchford's Calf Meal	25.	29.3
Quaker Oats Co., Chicago, Ill.	Schumaker's Calf Meal	19.	19.9
Boutwell Mill & Grain Co., Troy, N. Y.	Rye Middlings	...	15.1
Pioneer Cereal Co.	Barley Feed	...	12.9
H. W. Putnam, Bennington, Vt.	Ground Oats	...	12.3
Toledo Elevator Co., Toledo, Ohio	Star Feed	7.	8.1
Toledo Elevator Co., Toledo, Ohio	Star Feed for Live Stock	7.	8.8
POULTRY FEEDS			
Park & Pollard Co., Boston, Mass.	Dry Mash Feed	20.	28.9
Lapelle Poultry Food Co., Swanton, Vt.	Dry Mash Feed	20.	25.2
E. T. & H. K. Ide, St. Johnsbury, Vt.	Ideal Dry Mash Feed	...	23.9
Great Western Cereal Co., Chicago, Ill.	Sterling Scratch Feed	10.	11.4
Griswold & MacKinnon, St. Johnsbury, Vt.	Extra Good Scratch Feed	17.	11.5
Lapelle Poultry Food Co., Swanton, Vt.	Scratch Feed	10.	12.1
Lapelle Poultry Food Co., Swanton, Vt.	Gritless Chick Feed	13.8	13.4
Lapelle Poultry Food Co., Swanton, Vt.	Fattening Food	10.	10.4
Lapelle Poultry Food Co., Swanton, Vt.	Red Ribbon Chick Food	10.	11.3

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Lapelle Poultry Food Co., Swanton, Vt.	Growing Feed	14.	12.9
E. W. Conklin & Son, Binghamton, N. Y.	Arrow Chick Feed	11.5	12.7
Bowker Fertilizer Co., Boston, Mass.	Animal Meal	40.	44.
American Agricultural Chemical Co., New York, N. Y.	Beef Scrap	40.	55.

WHEAT OFFALS—RED DOG FLOUR

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Ogdensburg Roller Mills Co., Ogdensburg, N. Y.	Red Dog	...	16.7
B. McCrillis & Son, Boston, Mass.	Powerful	18.3	19.3

WHEAT BRANS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
David Stott, Detroit, Mich.	Stott's	...	16.7
F. W. Stock & Son, Hillsdale, Mich.	Stock's Pure W. W.	...	16.9
Rugby Mill Co., Rugby, N. D.		16.5	16.7
Crookston Milling Co., Crookston, Minn.	Coarse	...	16.7
Kemper Mill & Elevator Co., Kansas City, Mo.	Anchor	14.5	17.8
North Western Consolidated Mill Co., Minneapolis, Minn.	XXX Comet	17.	20.2
North Western Consolidated Mill Co., Minneapolis, Minn.	Pure	14.5	17.1
North Western Mill Co., Little Falls, Minn.	Fancy Spring	12.5	15.6.
Quaker Oats Co., Petersborough, Canada	Bell Cow	...	16.9
Washburn, Crosby Co., Minneapolis, Minn.	Coarse	14.5	17.6
Washburn Mill Co., Buffalo, N. Y.	Coarse	14.5	17.1
Chapin & Co., St. Louis, Mo.	Horse Shoe	14.	16.3
South Western Milling Co., Kansas City, Mo.		14.	16.7
Wm. A. Coombs Co., Coldwater, Mich.		14.	15.1
Hennepin Mill Co., Minneapolis, Minn.	Ben Hur, Coarse	14.	16.3
Bay State Milling Co., Winona, Minn.	Winona	15.	15.8
Pillsbury Co., Minneapolis, Minn.		14.5	16.3
G. C. Christian & Co., Ashton, So. Dak.	Pure	13.	17.3
Flour Mills Co., Winnebago, Minn.	Winnebago	14.	15.8

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Commander Milling Co., Minneapolis, Minn.	Commander	14.	15.1
A. B. McCrillis & Son, Boston, Mass.	Macco	14.2	16.7
David Stott, Detroit, Mich.	Stott's Pure Spring	...	17.1
	Monogram	...	16.7
F. W. Stock & Son, Hillsdale, Mich.	Stock's Pure Winter	...	16.
Eckhart & Swan Mill Co., Chicago, Ill.	Pure	...	16.3
The Gardners Mills, Minneapolis, Minn.	Clover Leaf	13.5	16.4
Barber Milling Co., Minneapolis, Minn.	Star Bran Flakes	13-17	18.

WHEAT MIDDLINGS

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
Washburn, Crosby Co., Minneapolis, Minn.	Standard	15.	18.9
W. H. Coombs & Co., Coldwater, Mich.	Fancy White	15.	16.4
	Pure Winter	15.	16.
Wirthmore Milling Co.	Wirthmore	15.	19.1
Red River Milling Co.	Shorts	14.	17.8
Bay State Milling Co., Winona, Minn.	Winona	17.8	19.5
F. W. Stock & Son, Hillsdale, Mich.	Stock's Pure Winter	...	18.4
Ogdensburg Roller Mills Co., Ogdensburg, N. Y.	Germ	...	20.6
National Milling Co.	Pure Wheat	...	19.5
Pillsbury Mills, Minneapolis, Minn.	Pillsbury B	15.	18.4
Pillsbury Mills, Minneapolis, Minn.	Pillsbury A	15.	19.3
New Prague Flour Milling Co., New Prague, Minn.	Seal of Minnesota	14.1	19.9
North Western Consol. Milling Co., Minneapolis, Minn.	Pure Wheat	15.8	17.1
G. C. Christian, Minneapolis, Minn.	Poland	14.	18.4
A. B. McCrillis & Son, Boston, Mass.	Powerful Flour	16.3	19.8
Valley City Milling Co., Grand Rapids, Mich.	Choice Vinco	15.8	16.9
W. J. Junnerson Co., Minneapolis, Minn.	Flour	11.	19.8
Washburn, Crosby Co., Minneapolis, Minn.	Adrian Flour	12.	19.8
Acme Evans Co., Indianapolis, Ind.	Hoosier Mill Feed	15.	17.1
Hunter Bros. Milling Co., St. Louis, Mo.	Matchless Mill Feed	15.	18.9

PROVENDER

MANUFACTURER OR JOBBER	BRAND	GUAR.	ANAL.
W. R. White, North Bennington, Vt.	Provender	...	9.0
F. M. Sherman & Co., Newport, Vt.	Provender	...	10.1
H. W. Putnam, Bennington, Vt.	Provender	...	9.9
F. M. Sherman & Co., Newport, Vt.	Corn Meal	...	8.6
E. W. Bailey & Co., Montpelier, Vt.	Corn Meal	...	8.3

2. CONCERNING THE RESULTS OF INSPECTION

Cottonseed meal. Twenty lots were examined. Five (Buckeye prime, Hunter Brothers' prime, American Cotton Oil Company's choice, Star and Imperial) were found from 1.1 to 2.6 percent below guaranty. Two lots (Imperial and an unknown) were unguarantied.

Cottonseed feed meal. Two lots, both sold by one firm, were sampled. One was decidedly short, 18.2 percent on a 22 percent guaranty. The jobbers of their own volition made a proportionate monetary refund to the local dealer, who in his turn furnished an affidavit that he would apportion the refund to the farmers who had bought the goods. The uneconomical character of this class of goods has been repeatedly pointed out in previous issues and is reiterated. Whether they maintain or do not maintain their guaranties, they are well worth letting alone.

Linseed meal. Seven lots were tested. One was unguarantied, the rest made their promises good.

Ground Flax Flakes. A single sample made good the makers' promises.

Distillers' Dried Grains. Sixteen lots were sampled and only two failed—Dewey's by 1.8 percent and Climax Grains by 2.2 percent—to meet guaranties. The sellers of the latter goods have lowered their guaranty 4 per cent and the March sample was of satisfactory grade. A marked improvement in this class of goods as to guaranty maintenance has taken place within the past two years.

Proprietary feeds. Ten lots were sampled. Two lots of local Vermont manufacture were unguarantied, faults which are now remedied.

Gluten feeds. Thirteen samples were drawn and all made good the promises made in their behalf. This is another class of goods which was once apt to fall below and now usually up to guaranty.

Molasses Feeds. Thirteen samples of these goods were analyzed. Two of these (Sugarota Dairy and Sugarota) failed by 2.6 and 1.3 percent to make good the protein claims appearing on the package.

Oat feeds; corn and oat feeds, etc. Twenty-two samples were tested. All were above guaranty. This was not a difficult feat to perform in view of the fact that but one was guarantied to carry more than 10 percent protein and but four others 10 percent, while ten of them were expected to contain but 7½ percent. This amount is less than the protein content of any commercial feeding stuffs (save roughages) except corn cobs, oat hulls, buckwheat hulls, and cottonseed hulls (see page 602). Indeed, it would be surprising if any of these goods should fail to maintain so low a guaranty as is placed upon them. Two lots were unguarantied.

Hominy feed. Three lots "made good."

Wheat offals. A great variety of wheat offals, bran, middlings, mixed feeds, red dog or feeding flour, were tested. Many of these were guarantied in accordance with the laws of other states. Without exception guaranties were maintained. The only case in the long list calling for special comment was the Dairy Winter mixed feed, which fully maintained its guaranty and carried the tag announcing, in accord with state law, that it was an admixture and not a pure wheat offal.

Provenders. Twenty lots seemed standard goods.

Corn meals and corn products. Nine lots were with one exception apparently straight goods. This one, Star feed, sampled at three points, is a hominy product with which ground corn cobs are mixed. The admixture is declared on the package.

Poultry feeds. Fourteen lots were analyzed. Three were low of guaranty, Wirthmore Mash, Extra Good Scratch and Growing Feed. The maker of the first named goods claims error in stencilling the sacks and that the wrongly marked sacks were used through error.

Miscellany. Five lots of rye and barley products seemed normal; two lots of ground oats seemed normal; two lots of proprietary calf meals met guaranties, and a lot each of alfalfa meal and dried beet pulp also met guaranties.

PRINCIPLES AND PRACTICE OF STOCK FEEDING

IV. ANIMAL NUTRITION

1. COMPOSITION OF THE ANIMAL BODY

The animal body contains many complex substances, but they may for present purposes be grouped as follows: water, ash or mineral matter, protein, and fat.

Water is the principal constituent of the animal body in point of quantity. From 40 to 85 percent of its gross weight, varying according to age and condition, consists of water. Indispensable to the life functions, it serves to impart elasticity, flexibility and rotundity to the bodily tissues. It is the great nutrient carrier and distributor, as well as the waste remover of the body. Yet notwithstanding, water has but little economic importance in this connection and needs no further consideration.

Ash (mineral matter) is a term applied to the residue or ashes left after complete burning. Bones contain much ash, while other portions of the body carry small quantities. From 2 to 5 percent of the gross weight of the frame is ash. It consists largely of phosphate of lime. While obviously essential to proper animal growth, ash exists in plentiful quantities in most rations and hence, like water, may be dismissed from further consideration.

Protein (the nutrient which forms flesh) is a term applied to a somewhat miscellaneous group of nutrients which, while highly diverse in a multitude of respects, are at least similar in that they all contain from 12 to 19 percent nitrogen. The proteids are the characteristic and special ingredients of the protoplasm which is the central feature of life itself. Three main sub-groups are recognized among the animal proteins, namely, the albuminoids, the gelatinoids (collagens) and the nitrogenous extractives. The *albuminoids* are the most important of these. The white of the egg, the dry, lean meat of muscle, and the casein of milk are albuminoids. The *gelatinoids* make up the elastic gelatinous part of bones, cartilages, tendons, etc., and are the basis of household gelatin and of glue. The *extractives* form the basis of meat extracts, beef teas, etc. The flesh, skin, bones (in part), vital organs, brain, nerves, in fact the bodily mechanism, are made up of protein, diluted, so to speak, with water, supported by the ash of the skeleton and rounded out with fat and with water. It is obvious that protein is of the utmost importance.

Fat is distributed throughout the normal body, although concentrated in adults in certain locations, such as around the kidneys, over the omentum, etc. It comprises from 6 to 30 percent of the live weight in different classes of animals. It consists of carbon, hydrogen and oxygen, but contains no nitrogen. While not as vitally necessary to the maintenance of animal life as are the other three ingredients, no one of which could be dispensed with, it serves certain bodily needs better than does protein, particularly that of reserve storage; and hence it has much economic interest.

These various substances exist in the animal, vegetable and mineral matters known as food, and are converted by the animals eating them, into flesh, fat, bone, milk, wool, and work (energy).

2. COMPOSITION OF VEGETABLE MATTER

Since the biblical statement that "all flesh is grass" is technically correct, it follows that the several constituents of animal and of vegetable matter are much alike. The various ingredients cited under the previous heading—water, ash, protein and fat—are found in feeding stuffs, as are also crude fiber (cellulose, woody tissue) and nitrogen-free extract (starch, sugars, gums, pentosans, etc.) The individual substances which comprise the groups when they are of vegetable origin are somewhat different from those in the animal body, but these variations are not important to present purposes.

These matters, having been recently discussed in bulletin 144, pages 44-45, will not be again reviewed here.

3. CERTAIN DEFINITIONS

While the generality of the technical terms used in this bulletin are defined in the glossary (pages 591-6) there are certain terms in common use in the discussion of the analyses of feeding stuffs, or in the discussion of nutrition, which are defined at the outset, in order that their meaning may be the more clearly apprehended by the reader.

Dry matter and digestible dry matter are collective terms. Neither represents any single group of nutrients. The first designates the material—whatever its nature—left when all the water it contains is vaporized. For instance, silage containing 75 percent of water carries 25 percent of dry matter. Digestible dry matter is a term applied to that portion of the total dry matter which the sundry digestive juices are able to render soluble and which becomes available as food. (See pages 546-555). It is true food, the remainder being useless except as it enriches the manure, or serves as a filler to maintain prompt and regular movements of the alimentary canal.

Nutrient and nutritive ratio are terms in frequent use. A nutrient is a digestible ingredient of food, one capable of performing one or more of the food functions. Ash, protein, fat and carbohydrates are nutrients. (See pages 537-538, 541-551).

The term nutritive ratio is less readily defined. The primary function of protein is quite different from that of the other nutrients (pages 542-543). On this account the relation of the amounts of digestible protein and of digestible carbohydrates and fat fed to our sundry domestic animals, both to the object in view, and to economy in feeding, is of importance. The nutritive ratio shows this relationship in a succinct and concrete form, in terms of figures. It is simply the mathematical expression of the relationship of the amounts of digestible protein to those of the other digestible nutrients occurring in a given ration. It is a ratio, a proportion, 1:6 or 1:8, the two terms of which are (*a*) digestible protein and (*b*) digestible carbohydrates and fat. If in a given case 2 pounds of *a* and 12 pounds of *b* are fed, the nutritive ratio of such a ration would be determined by the common rules of proportion, 2: 12::1: 6, there being 6 times as much digestible carbohydrates and fat as of digestible protein. Since a pound of fat has from 2.25 to 2.4 times the fuel value of a pound of carbohydrates, it is customary in calculating nutritive ratios, to multiply the weight of fat by either 2.25 or 2.4, and to add the result to the weight of the crude fiber and nitrogen free extract matter.

Nutritive ratios are termed "narrow," "medium" and "wide." A wide ratio is one affording a relative excess of digestible carbohydrates and fat; a narrow one, comparatively small amounts of these ingredients. Oat straw, for instance, is poor in protein and proportionately rich in carbohydrates; cottonseed meal is the reverse. The nutritive ratio of the straw is wide,—1 : 38.3; of the meal, narrow,—1 : 1.0. The method of calculating nutritive ratios is as follows: The amounts of digestible protein, carbohydrates and fat being found by the use of tables of analyses and digestion coefficients (pages 600-605), or, more readily, by the use of the convenience tables (pages 606-11) the amount of digestible fat, multiplied either by 2.25, or by 2.4 (the factor 2.25 is used in this bulletin and is the one in most common use today) is added to the amount of digestible carbohydrates, and the total divided by the amount of digestible protein. For example 20 pounds of red clover hay carries 0.4 pounds digestible fat, 7.6 pounds of digestible carbohydrates, 1.4 pounds of digestible protein; $0.4 \times 2.25 = 0.9$; $7.6 + 0.9 = 8.5$; $8.6 \div 1.4 = 6.1$. Nutritive ratio = 1 : 6.1, there being 1 part of digestible protein to every 6.1 parts of digestible carbohydrates and fat.

4. FUNCTIONS OF NUTRIENTS

Food as a whole may be defined as any material which is capable of forming or of repairing tissue (i. e. of replacing waste), or of yielding energy. Whether it perform only one or all of these functions, it still is food.[1]

The *water* content of feeds is a secondary consideration and may be disregarded in this discussion.

The *ash* of the food supplies the mineral portion of the bone, it furnishes minute proportions to other tissues; it serves to replace the constant wastage of mineral matter. Plentiful amounts are usually present to meet most demands. In exceptional cases, such, for instance, as young and growing animals, cows yielding very large amounts of milk, hogs exclusively corn fed, laying hens, etc., either carbonate of lime (oyster shells, chalk), wood-ashes, ground bone, or feeds rich in ash form a desirable addition to the ration because of the ash which they contain. That the body uses mineral matter is evident; but just how it uses it, that is to say just what is the method of its assimilation, is not well understood at present.

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[1] Food has been well defined as "the vehicle by means of which a tiny portion of the infinite and eternal energy from which all things proceed is placed for a short time at our disposal." (Quoted by Armsby in "Principles of Nutrition").

Protein, as has already been pointed out, differs from the other nutrients in that it is the "flesh former," the machine-maker, the repairer of wear and tear. It may, like the other nutrients, be used as fuel to run the machinery, but this is not a wise or economical use of this, the most costly nutrient in fodders and feeds.

a. From it are formed flesh, tendon, cartilage, blood, etc., and the nitrogenous ingredients of milk (casein, albumen, etc.)

b. It probably forms body fat, and, perhaps at times, milk fat.

c. It may furnish, when occasion requires, material for the production of heat to maintain the warmth of the body.

d. It may furnish, when occasion requires, material for the production of muscular energy.

e. It is held by some to be a stimulant to muscular and functional activities in general and to milk production in particular.

Let us consider these several functions somewhat more in detail.

a. The primary office of protein is that of tissue-building. It is the sole source whence may be made good the loss of proteids from the bodily tissues caused by the destructive action of the bodily processes. It is the sole source whence new tissue, other than fat, may be formed, since the body cannot make such from aught but proteids. This new or renewed tissue may be the flesh of a growing animal, the repaired or, rather, replaced flesh of a mature beast, the wool of a sheep, or the milk of a cow which in part at least is made from broken down udder tissue. Without protein, no flesh, hair, wool, or milk can be made. Animals fed on materials devoid of this nutrient have starved in the midst of plenty; and unless liberal supplies are accorded scanty returns may result.

b, c, d. The three functions of (*b*) fat formation, (*c*) heat making, and (*d*) the production of muscular energy are usually performed by the fat and carbohydrates of the food. If, however, these are insufficient in amount, protein may be consumed in their stead. Such shortage rarely occurs in cattle feeding, except when a ration is deficient in all the nutrients, that is to say when animals are being partially starved. Similarly protein may be used instead of fat or carbohydrates, if it is fed in excess of what is needed for making tissue or replacing waste. The protein thus used may be that of the food, or that of the body, i. e. flesh. The more is fed, the more is destroyed by the vital processes, if fed in excess of bodily needs. These three functions, however, may very properly be termed the secondary functions of protein, since these offices can be performed more successfully and more cheaply by the carbohydrates; and, as has been already observed, in ordinary feeding practice they are commonly thus performed.

e. It has long been known that, within certain limits, the more highly nitrogenous the ration, the greater is apt to be its potentialities as a milk maker. Protein, in other words, seems to act somewhat in the manner of a milk stimulant. Average milk carries from 3 to 3.5 percent albuminoids. A cow giving 30 pounds of milk a day yields therein a pound of protein (casein and albumen). The fat and milk sugar may be formed otherwise; but casein and albumen can only result from protein feeding, since, as above remarked, the body has no power to transmute elements or to make a nitrogenous nutrient, protein, from a non-nitrogenous food. The protein content of a ration profoundly affects the milk flow. Indeed it may not be too much to say that more than any other one thing it governs the effect of a given ration upon the milk flow.

Carbohydrates and fat are so similar in their offices in feeding that they may be considered in this connection as one. Their functions are five. They furnish material for the following purposes:

a. The production of heat.

b. The production of muscular energy.

c. The formation of body fat.

d. The protection of the flesh of the body from too rapid breaking down as a result of vital processes.

e. The manufacture of the non-nitrogenous organic milk constituents, i. e., sugar and fats.

There is no one function of the carbohydrates and fat which, like the flesh forming function of the protein, can be considered of more consequence than the others; all are of the utmost importance to the animal economy.

Let us now consider each of these five functions in more detail.

a. Carbohydrates and fat serve as the main supply of fuel wherewith to maintain bodily heat. Abundant supplies of the former nutrient being available in readily digestible forms in farm grown roughages, these afford its cheapest source. A certain temperature—that popularly known as "blood heat"—is necessary for the maintenance of the functional activities of the animal body. If this temperature falls below or rises above a certain point, death generally ensues. This heat is maintained by the destruction or burning of certain nutrients in the body. If sugar or starch were burned in a stove, heat would be produced and carbonic acid gas as well as other products would be formed. If. instead of being burned, the starch and sugar were eaten, they would be consumed by the vital processes of the animal, the same amount of heat would be evolved, and the same chemical compounds formed. The combustion would be slower, but the results would be the same.

b. Carbohydrates and fat are burned not only to keep the body warm, but also to produce the energy used in muscular motion and in the vital activities of the body. The analogy is often drawn between these nutrients and the muscular system on the one hand, and coal and the locomotive on the other; the carbohydrates and fat being regarded as the fuel and the muscular system as the engine. Any decided exertion of the body is accompanied by much increase in the expenditure of carbohydrates and fat. The nitrogenous materials suffer but little loss. Of course they are indispensable in the construction of the mechanism, yet the carbohydrates appear to be more vitally concerned in the actual energy production. Fat more than any other one constituent of the body appears to be available for this purpose. To it is usually accorded, for the heat producing function and for fat storage, from 2.25 to 2.4 times the value of carbohydrates.

c. If there is an excess of these nutrients eaten over what is required for the production of heat and energy, storage as fatty tissue may take place. Either nutrient may be used for this purpose, as may probably, at times, protein.

d. These nutrients, when digested, serve to protect the more costly protein from over-consumption by the vital processes. As has been pointed out hitherto, the several functions of the carbohydrates and fat may be performed by protein. Some usage of protein in this fashion is doubtless unavoidable at times, particularly by carnivora and omnivora; but with herbivora it is reduced to a low limit by ample supplies of easily digestible carbohydrates, which are ordinarily supplied by the use of the common farm grown roughages. These secondary offices of protein are held in abeyance, however, when the carbohydrates and fat are supplied in the usual ample quantities.

e. The ultimate source of the fat of milk was in controversy for many years. Protein, food-fat and carbohydrates have all been urged as the causal nutrient. While this point is perhaps not fully settled, Jordan's[1] results go far towards proving that carbohydrates are mainly concerned in the formation of milk-fat, since in a trial conducted by him some years ago a cow, fed for three months on a ration containing less than 6 pounds of digestible fat, gave 63 pounds of fat in her milk. This extra 57 pounds could not have come from previously stored bodily fat, since the cow gained 47 pounds in weight, and was judged to be fatter at the end than at the opening of the trial.

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[1] N. Y. (State) Sta. Bul. 132 (1898).

5. DIGESTIBILITY

The chemical analysis of a farm grown roughage or a purchased concentrate shows the crude nutrients it contains; but it gives no hint as to their availability for food purposes. All the food eaten is not digested. That which is dissolved by the sundry fluids of the digestive tract is assimilated; while the residual, undigested portion, together with intestinal debris, mucus, etc., forms the solid excreta or dung. The several ferments which attack the food in its passage through the alimentary canal render some of the nutrients—more in some cases, less in others, all in some, none in others—sufficiently soluble so that they are resorbed by the circulation and used in the maintenance or growth of the animal frame. The digested portions usually comprise the true protein and true fat (and do not as a rule include any material proportion of the non-proteids, such as the amids, extractives, etc., or of the non-fatty ether extracts) the more soluble carbohydrates (such as starches, sugars, and the like) and to a less degree the more resistant forms (such as the pentosans, cellulose, lignin, etc.). However, once digested, the more resistant forms of nutrients, unit for unit, have as great values for construction or other purposes as have the more readily available forms. (See in this connection, page 553).

The digestive systems of different species of animals vary as to their ability to handle food. The alimentary canal of a herbivorous or grass eating animal—the so-called ruminant—is able to digest a larger proportion of the crude nutrients from the coarser roughages than can that of a carnivorous or flesh eating animal. However, some of the food they eat, particularly the cellulose, is fermented largely by bacteria in the intestine and escapes from the body as gas. The matter thus lost is not reckoned as indigestible by the ordinary methods of a digestion trial, which are concerned solely with the food income and fecal outgo, thus constituting a source of error and indicating an over high availability of certain nutrients, more particularly the crude fiber which is prone to gaseous fermentation by the bacterial flora of the intestine.

The proportions of the total amounts of the crude nutrients which may be digested from a given fodder or feed are influenced by sundry considerations and conditions. The species of animal, its individuality, its age, as well as its physical activities, have bearing upon the outcome. Likewise the quantity of fodder fed, its condition as regards succulence or dryness, the method of its manipulation, the stage of its growth, its exposure to weather or to prolonged storage, the addition of concentrated feeds to a ration; all these, and doubtless many other causes, variously affect results.

Among the more important points which have been determined by experiment may be cited the following:

RELATIONSHIP OF ANIMAL VARIANTS

Species. Cattle and sheep show no marked differences in their relative abilities to digest feeding stuffs. Sheep digest the several nutrients in concentrates about as do cattle, assimilating and rejecting essentially the same amounts. The coarser roughages, however, seem to be handled somewhat more effectively by sheep. The digestive system of the horse, however, being less roomy and less complex than that of the bovine is necessarily a less efficient mechanism. Horses chew their food less thoroughly; insalivation is less satisfactory since they do not chew their cud; and their stomachs are smaller. Hence roughages, particularly the coarser ones, are less readily digested by the horse than by other domestic animals. Straw, for instance, possesses only about one-half and hay about three-fourths the food value for the horse that they do for the sheep. Concentrates are about as well digested by the one as by the other. The crude protein, regardless of its origin, seems about equally well handled by either. But the carbohydrates, particularly the crude fiber, and perhaps the ether extract, are not as well digested by the horse as by ruminants. Yet for reasons hitherto cited this difference may be in part apparent. Swine seem to digest the crude fiber of certain feeds better than do either horses or neat cattle.

Breed, Individuality, Age, Labor. No variations in digestive ability which may be attributed to breed differences have been observed. Different individuals may vary more or less in their capacities for digesting the crude nutrients, variations which may often be wider than those due to differences between breeds and species. Once the digestive system has fully developed, advancing age seems to have no effect upon the animal's ability to digest the several nutrients, until such time as the teeth or other organs become impaired by old age. Neither does labor, even when prolonged, so be it that it is not too severe, appear to affect digestibility. The data as to the effect of severe labor seems inconclusive. Hunger or the sight of food are generally held to augment the flow of such fluids as the saliva and the gastric juice, which contain certain of the ferments which are the active agents of digestion. Physiological trials seem to indicate that this excitation is psychic in character and due to nerve stimulus.

Similarly palatibility seems to favor the free flowage of the digestive fluids and, presumedly, the more rapid digestion of a ration, and a higher degree of digestibility of crude nutrients.

RELATIONSHIP OF FOOD VARIANTS

The order of feeding seems to have no material bearing, popular notions to the contrary notwithstanding; neither does the frequency of feeding seem materially to affect digestibility.

Quantity of feed. A large number of tests have shown practical uniformity as to the amount of the crude nutrients which are capable of digestion, and this seems true regardless of the amounts eaten.

Green or dry. If cut at the same time and stage of growth and if dried without loss of leaves, or exposure to rain or to heating (fermentation), drying does not appear to affect the digestibility of the nutrients. In actual practice, however, owing to the mechanical losses of leaves and other parts caused by the handling, the oxidations and fermentations which usually are inseparably and inevitably connected with the curing process, the leaching of the more soluble portions caused by exposure to rain, etc., dry fodders are as a matter of fact less digestible than are the same materials when fed in a green and succulent condition.

Hay grasses. Hay made in the most rapid manner with the least possible handling and dried only enough to insure its keeping, loses less of its finer and more digestible portions than when slowly made, much tumbled and exposed.

Stage of growth of the hay grasses. As the plant matures its cell wall thickens, but the cells themselves become more crowded with the better carbohydrates and less well filled with protein. The older, harder and tougher the cell wall structure, the less digestible it is and, furthermore, the better protection it affords to the cell contents against the attack of the digestive fluids. Hence the digestibility of a forage is lowered as the crop grows more mature. Then, moreover, the nutrients are in large part transferred to the seed as ripening becomes imminent. These, when lodged within the seed, are quite well protected against mastication or digestion, because of their small size and their hard and resistant seed coats. These small seed are apt to pass undigested through the alimentary canal and to be voided uninjured and capable of sprouting.

With corn, however, which is a mammoth grass, the situation is somewhat different. The same transference of proteids and other food nutrients to the seed occurs; but the seed is large and does not as readily escape mastication or digestion. The total dry matter of the plant is greatly increased during the last month or six weeks of its growth and, despite the lowering of digestibility, much more digestible dry matter is present in the mature corn crop than in the immature crop. This increase is mostly resident in the seed, for the digestibility of both stalk and leaf, that is to say the stover, is depressed in the same manner as in the case of the grasses. The more leafy a grass is, other things being equal, the more digestible dry matter it contains. The largest yield of digestible nutrients rather than extremely high digestibility should be the aim. This is not achieved by frequent cuttings of very young forage plants. Maximum amounts of digestible nutrients are generally attained when plants, particularly grasses, are cut in or shortly after full bloom. The earlier cuttings afford less yields than do the later cuttings, but enough better yields to more than offset the lowered quality.

Stage of growth of the legume hays. Legume hays are more bulky than are grass hays. When mature they carry a relatively higher percentage of crude fiber and are much more subject to mechanical losses and, consequently, are relatively less digestible, particularly if cut a little too late. The early cutting of legume hay is particularly desirable. In brief, the same influences which affect the digestibility of a grass hay affect those of a legume hay, only more so.

Straws are relatively woody, are apt to be lacking in the digestible nutrients, large proportions of which have been transferred to the seed, and are on the whole indigestible. The effort expended by the digestive system in endeavoring to assimilate such small amounts of digestible nutrients as they do contain, is frequently so great as to make the net contribution of food available for growth or replacement purposes comparatively small. (See in this connection, page 553).

Roots and tubers carry much water, a low fiber content, and a low protein content (much of which is in the non-proteid form, as amids, nitrates, etc.). The dry matter is made up largely of relatively soluble carbohydrates, (starches or sugars, gums, pectins, etc.). Their digestibility is high and their nutrients readily assimilated. Their dietetic effect is such as to make them a highly desirable addition to a ration; but they are costly to grow and their use is consequently restricted. A unit of digestible dry matter is doubtless raised more economically and more easily as corn than it is in the form of roots. It is stated that if the dry matter of roots makes up more than 15 percent of the dry matter of the ration, its digestibility is depressed unless nitrogenous concentrates are freely fed, in which case more than 15 percent of the dry matter of the ration can be made up of roots or tubers without causing such depression.

Concentrates carry a large amount of digestible nutrients in a small weight and bulk. In contra-distinction the roughages carry much weight and bulk in proportion to a relatively less digestible nutrient content. The one is easily, the other less easily, digested. Consequently, grain and grain byproducts form the main reliance of feeders for fattening and finishing animal products.

Mechanical preparation (cutting, grinding, cooking, steaming, etc.) The cutting of coarse roughages enhances the convenience of their handling and tends to promote their more complete usage; but it does not increase their digestibility, though doubtless lessening somewhat the labor of mastication and hence, perhaps, saving a modicum of bodily energy. On the other hand, it may perhaps lead to insufficient insalivation and, consequently, to depressed digestibility.

Grinding obviously augments the digestibility of grains. When eaten whole, more or less grain inevitably escapes mastication and, but slightly affected by digestive juices which are unable entirely to penetrate the resistant seed coats, passes through the alimentary canal and is voided. The loss is less with ruminants than with horses or swine. The question whether the gain from grinding, which is a more or less costly operation, will more than offset the loss is a moot one. If grinding costs in excess of ten percent of the value of the grain it is at best a doubtful proposition.

Cooking. Inferior food stuffs may be thus made more palatable, but the digestibility of normal feeds is, if anything, depressed. Potatoes, however, generally are held to be bettered by cooking; and swill, slaughterhouse refuse, etc. ought to be cooked in order to destroy the disease germs that may be present.

Ensiling vs. stooking. When corn is ensiled the mechanical losses due to handling are minimized, but those caused by fermentation are apt to be magnified. As low as from 2 to 5 percent loss from fermentation may occur in the silo; but doubtless 10 and 20 percent losses are more common, while in a leaky silo these may amount to 40 percent or more. The more soluble nutrients are those most readily fermented; hence, ensiling tends to depress digestibility. However, fermentative losses occur in stooked corn often, perhaps usually, in excess of those occurring in the silo, and mechanical losses are inevitably larger. The total digestible food losses are doubtless as a rule less when mature corn is properly placed in a good silo than when it is stooked.

Weather.—Wet or dry weather influences different crops on different soils variously, and affects digestibility in sundry ways.

Long keeping.—Many experiments show a lowered digestibility as a result of long keeping, due in some measure to loss of leaves which would entail a loss of relatively digestible portions and, also, to actual loss of dry matter.

Concentrated feeds added to coarse fodders—Protein.—A feed rich in easily digestible protein does not affect the digestibility of the coarse fodder. *Fat.*—Small quantities of fat seem to increase digestibility. More than ten ounces a day depresses digestibility. If not fed by itself but as oil cake or meal, more than this may be fed without causing such depression. *Carbohydrates.*—Additions of starch, sugars, etc., until they amount to 10 percent or more of the dry substance of a ration, tend to depress the digestibility, particularly of the protein and fiber. If the nutritive ratios exceed 1:8 some of the carbohydrates are similarly affected.

Grains and byproducts are more digestible than are roughages; immature crops than those which are mature; and ground feeds than those which are unground. Not only are those materials which are the more digestible the more serviceable, but they are apt to be the more serviceable to an extent which is out of proportion to their increased digestibility. This is particularly true of concentrates. A factor enters here which digestion trials do not measure nor digestion coefficients allow for, viz., the ease of digestion. The dry matters of rations A and B may be equally digestible, say 60 percent; but if it takes twice as long for the digestive system to make assimilable the digestible dry matter in ration A as it does that in ration B, the latter is the more efficient, in that less energy is expended by the digestive system in its effort, successful in both cases, to digest the food. The expenditure of energy is always at the expense of food hitherto eaten, and lessens by just so much the service of the ingested food as a tissue builder. This explains why a unit of digestive dry matter in a concentrate is usually more effective than is a unit derived from a roughage.

The distinction is made to some extent today between the *total energy* of a ration, i. e., its entire fuel value; the *available energy*, i. e., its entire fuel value minus the fuel or heat values of the materials voided in the feces, urine and intestinal gases; and, finally, the *net available energy*, i. e., its actual fuel value or maintenance value, after the losses in fuel value occurring in the dung, urine and intestinal gases are deducted, and allowance also made for the usage of heat values in the chewing and digestion of the food, which bodily processes are carried on as a result of the expenditure or usage of the stored material derived from food hitherto eaten.

DIGESTION COEFFICIENTS

Inasmuch as the rates of digestibility are unlike for the same nutrient occurring in different feeds, or fed under different conditions, or eaten by various kinds of animals, the determination of these rates for each feeding stuff in each condition and for each class of animal is a most necessary thing. This knowledge is gained by digestion experiments, wherein rations of definite composition are fed in known quantities and under known and definite conditions. After prolonged feeding with the experimental ration has cleared the stomach and intestines of the residues of other rations previously fed, the solid excreta as well as the food are weighed and analyzed for several days. Income and outgo are thus measured. The amount of the undigested crude nutrients passed in the dung, subtracted from the total amounts fed, indicates with some approach at accuracy the amounts digested. Repetition with many animals under diverse conditions serves to lessen the disturbing effect of individuality, and to favor an approximation to a true average. The proportions of each nutrient digested, expressed as percentages, are termed "digestion coefficients."

The conduct of a successful digestion experiment, although stated thus simply, requires much labor, is open to many errors, is beset by many difficulties, and the results are often quite unsatisfactory. Less stress is being laid by some upon the validity of data obtained using digestion coefficients than was formerly the case, owing to the clearer appreciation of the nature and extent of these errors and to the inception of more exact methods for the determination of net nutritive values. However, they have served and are still serving a very useful end, albeit their limitations are better understood than formerly.

A survey of digestion coefficients shows wide variations in different materials. From 6 to 94 percent protein, from 29 to 100 percent nitrogen-free extract, and from 19 to 100 percent ether extract is found to be digestible in different foods.

DIGESTIBLE NUTRIENTS

The amounts of digestible nutrients in a given fodder or feed are determined by multiplying the percentages of crude nutrients as determined by analysis by their respective digestion coefficients as determined by digestion trials. This calculation shows the pounds of digestible nutrients in 100 pounds. The calculation of clover hay is given below as an example.

	Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract
Analysis,	15.3	84.7	6.2	12.3	24.8	38.1	3.3
Digestion coefficients,	....	.57	...	.58	.54	.64	.55
Digestible nutrients,	....	48.3	...	7.1	13.4	24.4	1.8

6. CONCERNING TABLES OF ANALYSES, DIGESTIBLE INGREDIENTS, ETC., ETC.

Accompanying this bulletin—as an appendix—pages 590-611—will be found a very full glossary of definitions of the terms used (pages 591-596) and tables showing:

Table I. Feeding standards (pages 597-599).

Table II. The average composition—both as feed and as fertilizer—of the feeding stuffs most commonly used in New England. (With but few exceptions analyses of samples are from American sources) (pages 600-602).

Table III. The digestion coefficients determined by American experiment stations, and the digestible ingredients of the feeding stuffs the analyses of which occur in table II. (pages 603-605).

Table IV. The pounds of total dry matter, of digestible protein and of carbohydrates in varying weights of fodders and feeds. This latter table is essentially a convenience table, eliminating from the calculation of a feeding ration all but the final additions, and simplifying so far as possible the mathematics needed in figuring a ration (pages 606-611).

The data of analyses given in table II are selected from several sources. They represent the feeding stuffs in use today in this section of the country better than does any other set of tables known to the writer. This is particularly true as regards certain concentrated byproducts in large use in New England. Changes in the method of manufacture have been such that the analyses of 10 and 20 years ago differ decidedly from those of the goods sold today under the same trade names. The data of the analyses were carefully reviewed in the formulation of the tables as they appeared in bulletin 81 and have been again gone over painstakingly for the present issue; the digestion coefficients used are taken from the most complete and latest compilation of American experiments as given in Vol. III of the Cyclopedia of American Agriculture, pages 96 to 99, and from the compilation as published by Lindsey in the eighteenth Massachusetts station report, pages 224-248; the convenience tables have been made so as to meet almost any conceivable need; and all the calculations and figures in all the tables have been checked afresh and verified.[1] It is felt therefore that these tables are adapted for use in New England feeding practice. Maxima and minima are not included, nor are sundry details as to the stage of growth of certain crops. These are important items, but room for them is lacking. Such readers as desire to note the variations in composition among fodders and feeds of the same kind are referred to tables in farmers' bulletin 22 of the United States Department of Agriculture. It will be noted that the analyses and other data as to proprietary feeds, such as oat feeds, molasses feeds, etc., many of which are widely used, are omitted. This omission is intentional. Feeds of this character, the composition, formulas and make-up of which are subject to the whim of a manufacturer and the exigencies of commercial affairs, are obviously too open to change as the years pass by to render safe their inclusion in the tabular matter. The writer regrets that such were recognized and included in bulletin 81; and the past ten years' changes therein are ample justification of the decision to exclude them from the current issue.

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[1] Notwithstanding care, errors doubtless exist. The writer would appreciate notification of their detection.

V. FEEDING STANDARDS

1. THE NATURE OF FEEDING STANDARDS

Study of the sundry functions of the various nutrients shows that the rapidly growing animal, the deep milking cow and the heavy fleeced sheep need a liberal protein supply. It shows that the mature animal, kept without gain or loss, or simply laying on fat, needs relatively less protein, but much carbohydrates. Such study also shows that work consumes carbohydrates and fat, although using up muscle structure which can be built only of protein.

A knowledge of functions, however, furnishes no clue as to the proper proportions of the sundry nutrients for the various purposes for which stock is kept. And the next and obvious step is the determination of these amounts and proportions. How much protein, carbohydrates and fat and how much total food need be fed to the cow, the horse, the sheep or the pig, that each may do its best? What are the bodily needs of a given animal; what food will meet these needs; how much and what nutrient will maintain an animal without gain or loss; and how shall maximum production be attained at minimum expense?

A vast amount of experimental work has been done in Europe and in this country with a view of determining the fundamental laws of nutrition upon which rest the economical practise of stock feeding. While results of great value have been thus secured, our knowledge of underlying principles is still imperfect, though yearly increasing. Its incomplete condition, however, does not preclude the use of such information as is at hand in the formulation of the food requirements of farm animals; and this, despite the fact that newer methods of investigation raise doubts as to the validity of the method employed. Feeding experiments, the careful observation of practice and the study of animal nutrition have all contributed to this end; and, as a result, several "feeding standards" have been proposed. These are essentially the results of an attempt to state what in general and under usual conditions is a desirable return for a given purpose. These standards have been classified under three heads as the "physiological standard," the "formula for profit," and the "average feeding ration."[1] They may be termed the physiological, the practicable, and the average standards.

PHYSIOLOGICAL STANDARDS

The sundry physiological standards are meant to express the proportions of digestible nutrients best adapted to various animal needs and to the sundry purposes for which stock is kept. A large part of the total nutrients are required for mere maintenance, to keep the animal alive without deterioration. The residue, if any, is applied to production. Much experimental work with stock, mainly bovine, has afforded some notion of the relation between bodily needs and food supply. Yet differences among individuals, breeds and species, as well as fodders and feeds, environments, climates, care, etc., and among feeders, are wide; and, moreover, analytical methods are imperfect. Hence while physiological needs are known, absolute standards based on definite requirements cannot be fixed. They are both irrational and impossible. The use of these standards, then, is hedged about with many limitations which should be clearly apprehended, lest these formulas, which are extremely helpful if properly used, become misleading.

The physiological standards are clearly expressed, easily understood and readily used. On their face, if considered apart from the qualifications, they make stock feeding essentially a branch of applied mathematics. Their very simplicity and directness, however, are their fault, their strength is their weakness, for animal life and nutrition are too complex to be computed by mathematical rule.

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[1] Atwater, Conn., (Storrs) Sta. Rpts. 7, pp. 268-221 (1894); 10, pp. 112-119 (1897).

The study of the requirements of the individual animal and the adapting of food to its needs is to be preferred to placing the herd, as a whole, upon any inflexible ration. The capacity of an animal to receive, its ability to produce, the effects of the sundry feeds upon the health and condition of the animal, upon its appetite and taste, upon the quality of the product, the money values of feed and the profits to be derived from their use, are important considerations which do not enter into the makeup of the physiological standard but which are vital factors in the feeder's problem. Clearly the physiological standards may supplement and in some measure guide judgment, but cannot take its place.

Under the head of physiological standards, may be listed the original Wolff or "German" standards, the Kuehn standards, the Wolff standards as modified by Lehmann, and those proposed by Atwater and Phelps (Connecticut-Storrs-station standards.) It should be said, however, that the latter two standards take cognizance of the amount of the milk flow and its call upon the food supply as a factor in formulation. This important step in advance meets one of the principal objections urged in the past against the old Wolff or German standard.

PRACTICABLE STANDARDS. FORMULAS FOR PROFIT

"Physiological standards" contemplate maximum production only, cost being a secondary consideration. Yet the ration making the most may not be the most profitable. The various factors just mentioned as not entering into the makeup of the physiological standard are vitally important to the farmer; and these factors are variable one year with another, one place with another. Rations which may prove practicable and profitable, as well as fitted to animal needs, in New England may be ill adapted to the conditions obtaining in Colorado. Indeed, profit may follow quite diverse lines of feeding in the hill towns of Vermont from what would be advisable in the valleys. It may, for instance, pay better in some cases to grow more and to buy less, to feed a relatively wide ration, thus making less product but perhaps more profit. This is particularly apt to be the case in time when feeding stuffs rule high.

It is plain that no set "standards" have been or can be formulated to fit such variable circumstances. At times the old Wolff ration, again the Wolff-Lehmann or Storrs standards, or, indeed, often, neither of these, may suit certain conditions as they arise. Prolonged careful observation of feeding practise and experimentation may throw more light on this phase of the question, but at present it is safe to say that the practicable—because profitable—standard must be worked out for each feeder, each herd, each set of conditions independently, by close study of physiological needs, home and market resources and individual animals.

AVERAGE STANDARDS. AVERAGE FEEDING RATIONS

These standards, which for the want of a better term may be called average standards or, as an alternative, average feeding rations, are simply the reduction to a mathematical expression of the *average* practice of intelligent feeders, just as averages tell us that the average adult American male is five feet eight inches tall and weighs 155 pounds. "Standards" thus constructed may or may not be wisely used. The writer feels that they are more beneficial as information than as guides, and, it should be remembered, this is all that is claimed for at least one of the so-called "standards." Under this head may be classed the "standards" proposed by the Wisconsin,[1] the Connecticut (Storrs)[2] and Michigan[3] stations, as results respectively of the feeding practise of 128 and 32 herds and of a single herd.

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[1] Wis. Sta. Bul. 38 (1894).
[2] Conn. (Storrs) Sta. Rpt. 9, pp. 17-66 (1897).
[3] Mich. Sta. Bul. 149, pp. 85-96 (1897).

The latter case is perhaps hardly to be thus classified; yet in its place it may be found to be a practicable and profitable standard.

To recapitulate:

Physiological standards are not absolute rules but average estimates based on experimental work and upon the present knowledge of the physiological needs of farm stock. They are calculated to produce maximum results and take no cognizance of considerations of cost and other important items. The Wolff, Kuehn, Wolff-Lehmann and Connecticut standards are of this character.

Practicable standards consider the cost of raw material and of product as well as the yield, and are variables. Their use should entail profit. They may be said to be practically "home-made." They are the product of the experience, observation and study of the individual feeder, though they are often decidedly affected by the physiological standards.

Average standards are simply the expression of average feeding practice, apart from all considerations of adaptation to special needs, or ability to produce either large yield or profit. The Wisconsin standard, the Connecticut (32 ration) statement, and, perhaps, the Michigan standard are of this sort.

The remarks thus far made should serve to correct the misconceptions prevalent among feeders as to the true function of feeding standards. They are not rules but guides; not recipes but suggestions; not the mathematical expression of discovered natural laws, but the concisely stated results of practical experience linked with careful observation. They aim to state amounts and proportions of the sundry nutrients advisable under general and average conditions, or to indicate what in other and, often, many hands has done good service, without affirming that of necessity such a result will always be attained. These limitations once appreciated, the usefulness of the standards is beyond question. If, however, they are used without a clear understanding of their true character, they may become a stumbling block rather than a stepping stone. However, the large number of feeders who state that they have secured better returns as a result of modifying their feeding practices until they approximated those of the standards, would seem to warrant their continued use, until more definite, more accurate and more scientific data is at hand. These standards are not the last word in scientific cattle feeding; far from it. Indeed they are one of the first words, not yet made obsolete because thus far the better word has not been satisfactorily coined. Such is coming, but "not yet." However, in the interim they serve a very good, though temporary, purpose, until such time as the respiration calorimeter has illumined the last dark corner of that darkest of all dark places, "the inside of a cow."

The sundry standards thus far proposed, other than Kuehn's which have but small vogue, are given in the appendix (pages 597-600). The original Wolff standards were proposed over thirty years ago, but were revised by Lehmann a decade or more ago, with a view of making them harmonize better with the results of later experiments and experience. The only original Wolff standard printed in tables—that for cows—is the one which has had much the largest usage.

2. THE USEFULNESS OF FEEDING STANDARDS

Sundry questions naturally arise in the feeder's mind, as for example:

a. Why are the standards stated in terms of nutrients rather than of fodders and feeds?

b. Which of the sundry standards suggested are applicable to the feeding of one and the same class of animal shall be used?

c. When "doctors disagree" and when "ifs" and "buts" abound, may a farmer really find them useful?

d. What happens if standards are disregarded in feeding?

e. How does one go to work to make use of a standard and to formulate a ration?

These questions may be answered as follows:

a. Method of statement.—The standards are expressed in terms of protein, carbohydrates and ether extract instead of hay, corn fodder and bran in order to broaden their application. If stated as so many pounds of hay, silage, corn and cottonseed meals, it would be difficult for the feeder who had oat straw, corn stalks, clover rowen, bran and gluten meal, to know how to make up his ration. The standard being expressed in numerical form, it is a matter of the simplest figuring to construct an approximation to any desired ration.

b. Choice of standard.—Which standard to choose, for the cow for instance, is not a matter which should be settled dogmatically. Choice should be governed by many conditions which vary from time to time and from place to place, notably those connected with market prices for feeds and product. The feeder's judgment should likewise be an important factor. This has been already pointed out and will be again insisted on. It is the writer's opinion that given good cows, a good market for the product, not too high prices for concentrated byproducts, and an opportunity to grow fairly abundant supplies of leguminous crops, it will be found as a rule advisable to follow fairly closely the Wolff-Lehmann or the Connecticut formulas.

It should be remarked, however, that in most parts of the United States, carbohydrates are abundant and cheap, and protein relatively scarce and costly. This condition is reflected in the average feeding practice as shown by the Wisconsin and Connecticut investigations; and, as has been remarked hitherto, conditions may arise[1] which may make the wider ration the more practicable and profitable.

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[1] Conditions have arisen which serve frequently to make a wider ration than that hitherto fed more worthy of consideration than in bygone years. For now (1910) concentrates, which in 1900 cost $17 to $24, cost $31 to $36; and the words first penned in 1900 for conditions as they then obtained are less applicable today.

The reasons influencing the writer's opinion—which it may be remarked is in general accord with that of many if not most students of this matter—are that protein more than any other one nutrient seems to be a milk stimulant and to be a measure of milk production; that its reasonably liberal use means a better quality of manure; that the gradation of the food supply, and particularly that of the protein, primarily in accordance with the milk yield, and secondarily according to live weight, instead of solely by the latter, seems sensible; and that with good cows and a good market, a maximum yield, with due regard to health, is apt to be the cheapest yield.

c. Are standards of use?—Is it worth while to make choice and use of standards when they are hedged about by so many limitations, and when there are so many men of many minds? Emphatically, yes. Standards vary, judgments differ, cows, fodders and feeds are of all sorts and descriptions; yet better results would generally follow the adoption by most feeders of any standard, not only because of the change but because of the closer attention of the owner to his cattle, their care and their feeding which its adoption is likely to induce. A German adage says that "the eye of the master fattens his cattle." An old Vermont feeder assured the writer many years ago that his cows did better when he was around where he could "breathe on them."

d. Non-standard feeding.—What happens if the feeder follows no standard other than his own sweet will? Perhaps, but not as a rule, better results; more likely, a poorer outcome. His ration may suit his particular conditions. It simply does not correspond with those which the experience and judgment of others, the proposers of the sundry standards, have formulated. Departure from standards, if in the direction of lessened food supplies, is apt to result in lowered production, or, in some cases, in shrinkage in bodily weight, or both. If the variation is not in the amount, but in the proportion of the sundry nutrients, that which is fed in excess may be wasted, the yield or weight lessened, or, sometimes, a production other than the one desired may occur, as, for instance, increase in the flesh rather than in milk yield. If overfeeding is indulged in, if, for instance, too much cottonseed or gluten meals are fed, affording an excess of protein, there may be waste, the health of the animal perhaps may be endangered, or the quality of the product impaired.

It has already been pointed out that the physiological standards take no cognizance of economy, their aim being maximum production rather than low cost, the most production rather than the cheapest. Emphasis may again be laid on the fact that the individual feeder must determine for himself whether the greater profit is likely to follow higher production coupled with greater cost, or lower yield linked with lessened expenditure; whether the use of a home-grown, and, usually, wide ration is wiser than its supplement with purchased protein. It is safe to say, however, that in the long run the weight of evidence favors approximate conformity to standards whenever maximum yields are desired.

e. Figuring a ration.—How may one formulate a standard ration? What data are necessary and what are the mathematics of the calculation?

Two methods have vogue, the old time one of working more or less in the dark and trying different combinations until the desired end is attained; the other, proposed by Willard[1], involving the use of the mathematical process known as alligation. The process as conducted by the old time method is simplicity itself, mathematically, and is essentially one of "cutting and trying." Given certain roughages and grain feeds, definite weights are provisionally chosen, the pounds and fractions of a pound of total dry matter and digestible nutrients are added, and the result compared with standard. If fairly close, well and good, if choices were wise; if not, addition or subtraction of some one or more may be made with a view of improvement until the desired result is attained. The whole matter is most clearly explained by example. As has been already remarked, table IV in the appendix greatly simplifies the calculations. The process of calculation will be explained making use of this table and the full process will be elaborated (pages 606-611). The method of alligation is an ingenious one, which calls for rather more mathematics than does its predecessor, but once learned is rapid and accurate. Its method of use is shown on pages 570-572.

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[1] Kansas Sta. Bul. 115 (1903).

3. CALCULATION OF A FEEDING RATION

USUAL METHOD

It is assumed for purposes of illustration that a farmer has a cow weighing about 900 pounds, giving 30 pounds of milk a day, to which he wishes to feed a ration balanced according to the Wolff-Lehmann standard; that he has hay (timothy, Kentucky bluegrass, clover, etc., essentially "mixed grasses"), fairly mature corn silage, bran and cob meal; and that he can buy cottonseed meal, a distillers' dried grains, a molasses feed, mixed (wheat) feed, gluten feed and hominy chops. How shall he proceed to figure his ration? Reference to the standard shows that the 1,000 pound cow should be fed 32 pounds of dry matter, 3.3 pounds protein, 13 pounds carbohydrates and 0.8 pounds ether extract, nutritive ratio, 1: 4.5. The ether extract figures are multiplied by 2.25[1] and added to those of the carbohydrates; and then all the figures are multiplied by nine-tenths. This latter is done because a 900 pound cow weighs nine-tenths what a 1,000 pound cow does, and is held, according to the standard, to need approximately but nine-tenths the nutrition. As a matter of fact she probably needs a little more than this.

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[1] To reduce ether extract to the same fuel value and—it is assumed—feeding value as the carbohydrates.

$0.8 \times 2.25 = 1.8$. $13 + 1.8 = 14.8$. $32.0 \times .9 = 28.8$. $3.3 \times .9 = 2.97$.
$14.8 \times .9 = 13.3$.

The Wolff-Lehmann standard for a 900 pound cow giving 30 pounds milk, therefore, requires that the daily ration shall contain 28.8 pounds total dry matter, 2.97 pounds digestible protein, 13.3 pounds digestible carbohydrates and ether extract; and the nutritive ratio will be 1 : 4.5.

The next step is to supply these nutrients. The convenience table (pages 606-611) shows that bran alone of the feeds on hand has a nutritive ration (1 : 4.0) narrower than the standard. The hay, silage and cob meal have "wide" ratios, (1: 10.6, 1: 15.0, 1: 15.1), all wider than the standard. Hence purchases must be made; and these must be of feeds with narrow ratios. The materials available are found to have ratios as follows, ranging from narrowest to widest: cottonseed meal, 1: 1.3; distillers' dried grains, 1: 2.8; gluten feed, 1: 3.4; mixed (wheat) feed, 1 : 4.3, molasses feed (?)[1], and hominy chop, 1 : 10.6. It is at once perfectly clear that the latter two feeds will not aid in balancing the ration and that the mixed (wheat) feed will not be of much avail. Hence choice should be made of one or more of the first three according to price and others considerations. Let us assume that the cottonseed meal and gluten feed are chosen and proceed to figure our ration.

It is generally desirable to make as large use of roughages as possible because, being homegrown, they are relatively cheap. The amounts which can be consumed vary with different animals. In dairy feeding, however, much more than half and usually as much as two-thirds of the total dry matter should be given in the form of roughage.

Let us as a preliminary trial take 10 pounds mixed hay, 25 pounds silage from mature corn, 4 pounds bran and 1 pound each of cottonseed meal and gluten feed. Turning to the "convenience table" (pages 606-611) we find the total dry matter, digestible protein and carbohydrates, etc., calculated for these weights.

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[1] Bound to be a variable factor according to grade of goods, but always, as at present made, relatively wide.

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.	Nutritive ratio
Hay, 10 pounds	8.5	0.42	4.5	
Silage, 25 pounds	6.5	0.28	4.2	
Bran, 4 pounds	3.5	0.48	1.9	
Cottonseed meal, 1 pound	0.9	0.36	0.5	
Gluten feed, 1 pound	0.9	0.20	0.7	
Total	20.3	1.74	11.8	1:6.8
Standard	28.8	2.97	13.3	1:4.5

How do the totals and the standards compare? A casual survey shows that the former are 8½ pounds short in total dry matter, 1¼ pounds short in protein, 1½ pounds short in carbohydrates; that the first attempt is 30 percent lacking in dry matter, 40 percent in protein, but is only 12 percent short in carbohydrates. What shall be used to bring the ration up? More roughage will increase carbohydrates faster than protein; more bran will do the same, but not as rapidly; more cottonseed meal will not, and more gluten feed will help more than it will hinder. Inasmuch as it is of doubtful wisdom to feed cottonseed meal very heavily, let us see what the addition of two pounds each of cottonseed meal and of gluten feed will do.

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.	Nutritive ratio
Cottonseed meal, 2 pounds	1.9	0.72	1.0	
Gluten feed, 2 pounds	1.8	0.40	1.4	
	3.7	1.12	2.4	
Former result	20.3	1.74	11.8	
Second total	24.0	2.96	14.2	21:4.8
Standard	28.8	2.97	13.3	1:4.5

The ration is somewhat too wide, yet lacks in total dry matter by nearly 5 pounds. To narrow it one would withdraw roughage; yet to do this will still more reduce bulk. It is difficult or impossible to do both, though bulk without much nutriment could be furnished by straw; but as a matter of fact this is not very important.

Let us withdraw two and one-half pounds of hay and see where we stand.

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.	Nutritive ratio
Former results	24.0	2.96	14.2	1:4.8
Hay, 2½ pounds, withdrawn....	2.2	0.10	1.1	
Final total...............	21.8	2.86	13.1	1:4.6
Standard	28.8	2.97	13.3	1:4.5

The result is still low in total dry matter while giving plenty of nutrients. It is also slightly lacking in protein, but not enough so to worry about. The ration lacks slightly in bulk but not in food. To try and obtain bulk with the fodders on hand would result in feeding more than the standard amounts of the nutrients. A ration of 7.5 pounds hay, 25 pounds silage, 4 pounds bran, 3 pounds cottonseed meal and 3 pounds gluten feed would meet the Wolff-Lehmann standard requirements for a 900 pound cow with a sufficient approximation to accuracy for all practical purposes.

This is a very narrow ration, and, if ever adopted, should be used with caution, particularly at the outset. Three pounds of cottonseed meal is a somewhat heavy feed for the generality of cows, heavier than is often desirable. Were half this cottonseed replaced by linseed, the ration would be the safer and be but a trifle poorer in protein.

The longer and complete figuring is carried out as follows: The average analysis of mixed hay, so far as it pertains to the ingredients called for in the determination of the standard, is as follows (Table II): Dry matter 84.7 percent (100—15.3 percent water), crude protein 7.4 percent, crude fiber 27.2 percent, nitrogen-free extract 42.1 percent, ether extract 2.5 percent. The digestion coefficients for these ingredients are respectively

(Table III), .57, .60, .61 and .50. Multiplying each percentage by its digestion coefficient gives the digestible ingredients in 100 pounds (Table III), protein, 4.2 (7.4×.57), crude fiber, 16.3 (27.2×.60), nitrogen-free extract, 25.7 (42.1×.61) ether extract, 1.3 (2.5×.50). Adding the fiber and the nitrogen-free extract and 2.25 times[1] the ether extract for "carbohydrates and ether extract," we get 44.9. Ten pounds of hay being fed, each figure is multiplied by .10 (10 being 1-10 of 100) with results as follows: In 10 pounds mixed hay, total dry matter 8.5 pounds, protein 0.42 pounds, carbohydrates, etc., 4.5 pounds. These are the figures given in the top line of the table on page 568, which were read directly from the convenience table (Table IV) half way down in the left hand side of page 607. The use of this table obviates this tedious though simple calculation.

CALCULATION BY ALLIGATION

The method of alligation is employed in the determination of a balanced ration in the following fashion. The desired nutritive ratio being known, one selects two feeding stuffs which seem desirable ingredients of the proposed ration, one of which has a narrower and the other a wider nutritive ratio than has that chosen for the final product. The procedure is then: (1) The second term of the final ratio is subtracted from that of the less proteinous feeding stuff and the results multiplied by the "protein equating factor" of the other feed. (2) The second term of the ratio of the more proteinous feed is subtracted from that of the final ratio and the result multiplied by the "protein equating factor" of the other feed. (3) The two results thus attained give the relative proportions of each feed to be used; not of necessity, or usually, the amounts to be used, but the proportions in which they are to be used. If these two figures are added and each number be divided by their sum, the relative proportion in a pound of each will be determined.

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[1] **Ether extract × 2.25 added. See foot note, page 566.**

The "protein equating factor" is simply a figure showing the weight of a given feeding stuff which contains a pound of digestible protein. Thus alfalfa hay carries 10.3% digestible protein. If now one makes the proportion 10.3:100::1:x the last term x = 9.71; or, translating figures into words, if there are 10.3 pounds of digestible protein in 100 pounds of alfalfa hay, there is 1 pound of digestible protein in 9.71 pounds of the hay. And 9.71 is the protein equating factor, the figure used in the rule. The nutritive ratio and protein equating factor of each roughage and concentrate are to be found in the right hand columns of table II on pages 600-602.

Assuming that it is desired to determine by the alligation method the same ration as has just been worked out on pages 566-569, the procedure would be as follows:

The nutritive ratios of the hay and silage are wider, of the cottonseed meal and gluten feed narrower, and of the bran not materially unlike that of the proposed ration. The first four may be coupled thus: hay and cottonseed, silage and gluten. The figuring then is as follows:

Hay: nutritive ratio.......1:10.6	**Desired ration: nutritive ratio 1:4.5**
Desired ration: do. 1: 4.5	**Cottonseed meal: do. 1:1.3**
Difference 6.1	**Difference 3.2**

Cottonseed meal 6.1× 2.8 (P. E. F. of C. S. M.) = 17.1 18%
Hay............3.2×23.8 (P. E. F. of hay) = 76.2 82%

Total.................................. 93.3
93.3:76.2::100:x=*82* **93.3:17.1::100:x=*18***

Silage: nutritive ratio.....1:15.0	**Desired ration: nutritive ratio 1:4.5**
Desired ration: do. 1: 4.5	**Gluten feed: do. 1:3.4**
Difference 10.5	**Difference 1.1**

Gluten feed.....10.5× 4.9 (P. E. F. of G. feed) = 51.5 34%
Silage.......... 1.1×90.9 (P. E. F. of silage) =100. 66%

Total................................ 151.5
151.5:100::100:x=*66* **151.5:51.5::100:x=*34***

Any mixtures of any amounts of cottonseed meal and mixed hay in the proportion of 18 to 82 or of 1 part of the one to 4.55 of the other, will be balanced in the sense of having a nutritive ration of 1: 4.5, assuming of course that the composition and digestibilities of the two components are essentially identical with those which are accepted as the standard. Similarly any combination of gluten feed and of silage in the proportion of 34 to 66 or, practically, of 1 to 2—assumptions being as in the previous sentence—will be balanced. And, obviously, any mixture of the two mixtures will be "balanced." And, finally, bran, being of nearly the same balance as the ration, may be used *ad libitum* without much effect on the balance. With these facts in mind, let us proceed. If one should make a combination of cottonseed meal, 2 pounds; hay, 9 pounds; gluten feed, 3 pounds, silage, 6 pounds; bran, say 5 pounds, the ration thus formed will balance 1:4.5. It will carry 9 pounds of hay, 6 pounds of silage, 10 pounds of grain and furnish but about two-thirds the total dry matter needed, and three-fourths the digestible protein and digestible carbohydrates. It obviously would be a faulty and ill-adapted admixture. In short the employment of this method enables one promptly to arrive at a "balance," but it is not adapted quickly to enable one to determine the amount of nutrients to be fed. Furthermore the method seems better calculated to the computation of simple rations of two or three components than to the determination of the make-up of the more complicated ones commonly used in dairy feeding.

In this connection mention should be made of the methods of calculation which it seems safe to assert will, in the course of time, replace those now in vogue; those dealing not with the potential values of feeding stuffs, but with their productive values. A great deal of elaborate, painstaking and highly accurate work has been done, both in Germany and in this country, looking toward the determination of actual food values, using the refined methods of the respiration calorimeter. A considerable volume of data is at hand. However, the present status of the matter is essentially as follows: Enough has been done to indicate the likelihood that many of the standards hitherto used and relied upon (such as those shown on pages 597-599 of this bulletin) are of doubtful validity; that the methods of experimentation on which the "balanced ration" proposition has been erected are not without fault; and that the results attained thereby are to some extent incorrect. But as yet the volume of available and accurate data, determined by methods which take cognizance of, or either avoid or measure, these errors is either insufficient for use, or is not sufficiently well moulded into shape. And, pending the time when the newer figures are finally settled, the older ones are quite commonly employed in the belief that though not strictly accurate their use is well worth while, but with less assurance as to their validity than was formerly possessed.

4. PLANNING A SEASON'S FEEDING[1]

The farmer who plans his season's feeding ahead is naturally controlled as to his procedure largely by the nature and the amounts of the roughages he has on hand or can grow. His cattle are used essentially as means of converting relatively unsaleable farm products into such as will sell. The farm grown roughages will inevitably form the bulk of the diet, and the general tendency of feeders is to seek the largest profit from their use rather than to provide a standard ration regardless of cost.

Farm grown roughages and farm grown grains are not well adapted to form the sole support of cows. Hence the question arises at the outset whether sales may not be made from the farm and the receipts applied to the purchase of higher grade feeds. May not timothy hay and grain be sold and bran, cottonseed meals, distillers' grains and the like and, possibly, clover hay be bought, without much if any extra outlay and to the actual improvement of food and manurial supplies? The tables of analyses, digestible ingredients, fertilizing ingredients, etc., in this bulletin, (pages 600-605) together with a knowledge of market prices and a little figuring, will enable anyone of experience and judgment in cattle feeding to answer this question for himself and to plan his feeding operation intelligently to this end.

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[1] **This section is greatly modified in the revision, by the substitution of certain feeding stuffs now sold but not formerly offered for goods then purveyed but now withdrawn, and by using the prices of 1910 instead of 1900.**

The following suppositious case is worked out at length by way of illustration. It is recommended to the careful consideration of feeders who find it difficult to gain the wherewithal to purchase feeding stuffs.

A herd of 20 cows, averaging 1,000 pounds in weight, are to be fed in the barn from fall to spring, i. e., for 200 days. The roughages and grain mentioned below are available, being farm grown, and are assumed to have the following sales values in the vicinity.

25 tons timothy hay	$15	a ton
10 tons clover hay	10	a ton
80 tons silage (mature corn)	3.50	a ton
300 bushels oats		50 cents a bushel

There are also on the farm seven tons of oat straw, worth, say, $5 a ton, which it is designed to use as bedding, but which may be fed if needed.

The following feeds may be bought in the neighborhood at the prices named:

Corn meal	$30	a ton
Wheat bran	29	"
Wheat middlings	32.50	"
Mixed (wheat) feed	32	"
Cottonseed meal	34	"
Linseed meal, new process	36	"
Distillers' dried grains	33	"
Gluten feed	33	"
Molasses feed	30	"

What, if any, sales and purchases may be made in order to winter the herd successfully, to render more likely the securance of a better milk yield and at the same time to involve little or no extra outlay of money, and, finally, to avoid any serious depletions of the plant food supply of the farm?

The feeding of twenty cows for 200 days is equivalent to the feeding of one cow for 4,000 days. The sundry standards prescribe the following amounts of dry matter and nutrients for 4,000 days; and the home grown hay, silage and oats furnish the amounts shown below:

	Dry matter	Organic matter	Digestible protein	Digestible carbohydrates[1]	Nutritive ratio
Wolff	....	96,000	10,000	53,600	1: 5.4
Wolff-Lehmann (medium)	116,000	......	10,000	56,400	1: 5.6
Wisconsin	98,000	......	8,600	59,800	1: 7.0
Connecticut (medium)..	....	96,000	11,600	57,600	1: 5.0
Hay, silage and oats....	111,000	......	5,600	65,300	1:11.7

The total dry matter on hand in the hay, silage and oats is about right. There is a moderate excess of carbohydrates, but protein is seriously deficient, and the nutritive ratio excessively wide. Roughages are in excess and grain feed lacking.

It is plain that if sales and purchases are made, feeds rich in carbohydrates should be sold and those rich in protein bought. Timothy hay and oats are readily saleable and have wide nutritive ratios—1 : 14.3 and 1 : 6.2—and a pound of digestible dry matter therein is worth more commercially, or, in other words, sells at a higher price—at the assumed prices—than would a pound of digestible dry matter in the clover hay and silage. This is evidenced in the following showing:

	100 pounds	Pounds of digestible dry matter	Cost of one pound of digestible dry matter
Timothy hay	$0.75	49.5	1.52 cents
Clover hay	0.50	48.3	1.03 "
Silage	0.17½	18.7	0.94 "
Oats	1.56	62.3	2.50 "

The cottonseed and linseed meals, the distillers' grains and gluten feed have narrow nutritive ratios, as has also clover hay, and their digestible dry matter and protein are relatively cheap. It will be wise, therefore, to sell costly dry matter—timothy and oats—and to buy cheaper, and, for cow feeding purposes, better dry matter—cottonseed meal and the like.

Let us assume that a market is found for all the timothy hay and oats. There will have been sold and there will remain on hand amounts of dry matter and nutrients as shown herewith:

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates[1] lbs.
Sold: 25 tons timothy hay and 300 bushels of oats	51,900	2,300	28,600
Left on hand: 10 tons clover hay and 80 tons of silage..................	59,100	3,300	36,700

Our feeder has now little more than half the dry matter needed, but two-thirds the carbohydrates and only one-third the protein. But he has received $525 from the sale of hay and oats which he may invest in the purchase of feeds better adapted to his purpose.

The roughages left on hand would admit of feeding 5 pounds clover hay and 40 pounds silage a day to each cow. This is a full-sized silage ration for a 1,000 pound cow. It would be eaten if a minimum of hay were fed. The hay and silage would furnish 15 pounds of dry matter, or nearly two-thirds of the total called for by most standards. It is perhaps questionable whether more clover hay and less silage would not be an improvement. The former being found on sale at $10,[2] 5 tons are bought, and the residue of the silage not used by the cattle in the 200 days of barn-feeding—say 20 tons—is kept for use in summer to help out the pastures.

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[1] Ether extract × 2.25 added to the nitrogen-free extract.

[2] Not often will clover hay be found on sale on Vermont dairy farms. If the writer were formulating this article afresh he would have assumed 15 tons grown and have bought none; and the financial outcome of the suppositious case under review would have been so much the better.

Our feeder now concludes to adopt the Lehmann standard as a guide and to fit his calculations to the medium standard, as being on the whole a fair average for the winter. He has on hand:

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.
15 tons clover hay	25,400	2,100	12,600
60 tons silage	31,600	1,400	21,200
	57,000	3,500	33,800
This is short of standard for 4,000 days' feeding	59,000	6,500	22,600

He has $475 left unexpended. He can feed 7½ pounds of clover hay and 30 pounds silage daily to each cow, giving her thus from 14 to 15 pounds of dry matter in roughages, when 29 pounds in all is required.

And now for buying. His study of market prices, of the tables of digestible ingredients, (pages 603-605) and his knowledge of the effects of various feeds upon animal health and the quality of the product lead him to choose bran, cottonseed and linseed meals and distillers' dried grains. Corn meal and the molasses feed are not bought, being relatively costly and not adapted to his needs; and, moreover, the silage is from mature corn well eared. Bran is chosen, despite that high price which makes it almost a luxury rather than a necessity. It is chosen rather than middlings or mixed feed as the wheat offal, not because it is cheaper or as digestible, but because of its good mechanical effect on the ration, its well-recognized milk-making properties, and its safety when fed in any amount. Moreover, its dry matter and protein are but little more costly than those in the other wheat offals. Distillers' dried grains are a highly satisfactory concentrate, light, bulky, relatively rich in protein, safe to feed. Cottonseed meal is chosen for use to the limit permissible, being rich in digestible protein, which, moreover, is the cheapest on the market. Linseed meal is a good laxative, has counter effects on animal and product to cottonseed, is preeminently healthful, and moreover is not now comparatively as expensive as it was in former days.

As a matter of convenience let us fit protein needs first and then note how closely other requirements will be met. 6,500 pounds of digestible protein would be furnished by 27 tons of bran, by 8¼ tons cottonseed meal, by 10 tons linseed meal, or by 11 tons of distillers' dried grains, costing respectively $781, $280.50, $360 and $363. The amount on hand is $475. Clearly the bran purchase should not be large, looking at the matter purely from the side of dollars and cents. Yet the safety of bran already referred to, and its good effect in lightening the grain ration, are worth a good deal. Let us figure on 3 tons bran, 2½ tons cottonseed, 1 ton linseed, 3 tons distillers' grains. These will calculate as follows:

	Digestible protein percentage	Pounds of digestible protein	Cost
6,000 pounds bran	12.	720	$ 87
5,000 pounds cottonseed meal........	35.2	1760	85
2,000 pounds linseed meal...........	32.5	650	36
6,000 distillers' dried grains.........	24.	1440	99
		4570	$307

There is still a shortage of 1,930 pounds of protein, but there are $168 left unexpended. Let us add more bran and linseed meal—for safety and health—and more cottonseed meal.

	Digestible protein percentage	Pounds of digestible protein	Cost
2,000 pounds bran	12.	240	$ 29
3,000 pounds cottonseed meal........	35.2	1050	51
2,000 pounds linseed meal...........	32.5	650	36
		1940	$116
Former total		4570	307
		6510	$423
Left on hand......................			52

The lacking protein is bought and the money is not all spent. A ration of 7½ pounds clover hay, 30 pounds silage and 6½ pounds of these byproducts will supply the needed protein. It should be remarked, however, that this would not be the case were any hay used but clover hay.

Will this ration furnish the dry matter and carbohydrates needed?

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.
8,000 pounds bran	7,100	960	3,620
8,000 pounds cottonseed meal.........	7,300	2,810	3,200
4,000 linseed meal	3,600	1,300	1,700
6,000 distillers' dried grains..........	5,500	1,440	3,900
Total......................	23,500	6,510	12,450
Standard requires in addition to the nutrients on hand in the hay and silage	59,000	6,500	22,600

The protein calculates all right, but dry matter is nearly 18 tons, and digestible carbohydrates 5 tons, short of what is needed to balance. Casting about for means to meet this condition the farmer finds that his oat straw will be of use. It contains plenty of dry matter, but little digestible protein and plenty of digestible carbohydrates. He finds on reference to the tables that his 7 tons of straw will furnish 12,700 pounds dry matter, 170 pounds of digestible protein, and 6,400 pounds of digestible carbohydrates. If he uses it his ration will still be left short in dry matter and carbohydrates and it will be a good deal narrower than standard. More oat straw, if purchasable, would fit in here. It might bring $6 a ton; 4 tons may be bought containing 7,250 pounds of dry matter, 100 pounds of digestible protein and 3,700 pounds of digestible carbohydrates. This uses $24 of the $52, leaving unspent $28.

Now to sum up:

	Dry matter lbs.	Digestible protein lbs.	Digestible carbohydrates lbs.	Nutritive ratio
15 tons clover hay............	24,500	2,100	12,600	
60 tons silage	31,600	1,400	21,200	
4 tons bran	7,100	960	3,650	
4 tons cottonseed meal......	7,300	2,810	3,200	
2 tons linseed meal..........	3,600	1,300	1,700	
3 tons distillers' dried grains.	5,500	1,440	3,900	
11 tons oat straw	1,990	270	10,100	
	100,400	10,280	56,350	1:5.5
Lehmann (medium) standard, 4,000 days	116,000	10,000	56,400	1:5.6

The ration would be lacking in bulk, but otherwise closely like the standard chosen. The shortage in bulk is not serious. Indeed, the Lehmann requirement for dry matter is much in excess of that of any other standard and is somewhat difficult to attain.

The ration as formulated has more protein than is needed by nearly 300 pounds. The question now rises whether so much grain feed is needed. May not less cottonseed or linseed be bought and some money be saved? One could save the most by lessening the linseed, but it would probably be wiser to curtail the usage of the cottonseed. If 800 pounds of cottonseed meal be withdrawn, $13.60 will be saved. The protein would be reduced to 10,000 pounds, carbohydrates to 56,000 pounds, total dry matter to 99,700 pounds, while the nutritive ratio would become 1 : 5.6. The $13.60 should buy enough sawdust to nearly or quite equal the absorbent value for stable uses of the 4 tons of oat straw.

The outcome of the operation, so far as food is concerned, is as follows: Without the outlay of an extra dollar, timothy hay and oats have been exchanged for clover hay, oat straw, bran, cottonseed and linseed meals and distillers' dried grains; a ration well adapted to milk making is obtained in place of one ill fitted to that end; and $41.60 is in hand in addition. Moreover 20 tons of silage remain on hand as a reserve stock for summer feeding. The final ration for 4,000 days and the average ration for a single 1,000 pound cow are as follows:

	Four thousand days				One day			
Fodders and feeds	**Weight**	**Dry matter**	**Digestible protein**	**Digestible carbohydrates**[1]	**Weight**	**Dry matter**	**Digestible protein**	**Digestible carbohydrates**[1]
	tons	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Clover hay	15	25,400	2,100	12,600	7½	6.35	0.53	3.15
Silage	60	31,600	1,400	21,200	30	7.90	0.35	5.30
Oat straw	11	19,900	270	10,100	5½	4.98	0.07	2.53
Bran	4	7,100	960	3,600	2	17.7	0.24	0.91
Cottonseed meal	3⅗	6,600	2,530	2,850	1⅘	1.83	0.64	0.71
Linseed meal, N. P.	2	3,600	1,300	1,700	1	0.90	0.33	0.43
Distillers' dried grains	3	5,500	1,440	3,900	1½	1.38	0.36	0.98
		99,700	10,000	56,000		25.11	2.52	14.01
Wolff-Lehmann (medium) standard		116,000	10,000	56,400		29.0	2.5	14.1

How about fertilizing ingredients? Have not the sales of hay and oats seriously depleted the resources of plant food? A comparison is needed here between sales and purchases.

	Nitrogen lbs.	Phosphoric acid lbs.	Potash lbs.
Sales. 25 tons timothy hay	470	265	450
4⅘ tons oats	181	79	60
Total fertilizing ingredients sold	651	344	510
Purchases. 5 tons clover hay	197	38	220
4 tons bran	197	261	128
3⅗ tons cottonseed meal	472	207	135
2 tons linseed meal	244	73	56
3 tons distillers' dried grains	312	39	8
Total fertilizing ingredients bought	1,422	618	547

The sundry purchases bring upon the farm more than twice as much nitrogen as is removed, they add almost as much again of phosphoric acid as the sales remove, and replace the potash which is sold. The increase in manurial constituents due to the exchange of feeds low in plant food for those rich therein, if rated at market prices for the same ingredients in commercial fertilizers, is worth $165.37. All of this will not become available to future plant growth because of inevitable losses of one sort and another, but it is clear that from the standpoint of plant food the operation promises success.

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[1] Ether extract × 2.25 added to the nitrogen-free extract.

The final outcome of the sale of timothy hay and oats and the purchase of clover hay and byproducts in this case is *more food, more milk, more butter, more and better manure, more profit, some outlay of brains, but no outlay of money.*

Although this case is suppositious and doubtless often could not be duplicated, yet results similar in kind if not in degree might be attained on thousands of Vermont farms, to the benefit of both land and occupants.

VI. SUNDRY ECONOMIC CONSIDERATIONS

1. CLASSIFICATION OF ROUGHAGES AND CONCENTRATES

Lindsey[1] has classified the cattle fodders and feeds in more common use in a clear manner, basing the scheme upon the relative proportions of digestible protein and of digestible carbohydrates contained. His classification, somewhat modified and extended, is presented herewith.

ROUGHAGES

1. *Low in digestible protein, high in digestible carbohydrates.*

   Hay, grasses (other than pasture grass), corn silage, fodder and stover, cereal fodders, straws, (45-75 percent digestible); roots, potatoes, (75-95 percent digestible).

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[1] Mass. (State) Sta. Bul. 39, pp. 11, 17 (1896).

2. *Medium in digestible protein, high in digestible carbohydrates.*

   Clovers, pasture grass, rowen, oats and peas, barley and peas, legumes in general; all either green, hayed or ensiled, (50-70 percent digestible).

CONCENTRATES

1. *Low in digestible protein, medium in digestible carbohydrates.*

   Oat hulls, cottonseed hulls, cottonseed feed, (40-70 percent digestible).

2. *Low in digestible protein, high in digestible carbodrates.*

   Grains (except peas and beans), corn meal, cob meal, provenders, corn and oat feeds, barley screenings, wheat screenings, hominy chop, certain oat feeds, (70[1]-90 percent digestible).

3. *Medium in digestible protein and carbohydrates.*

   Certain so-called dairy feeds, molasses feeds (as a class), wheat and rye brans, brewers' dried grains, malt sprouts, (62-80 percent digestible).

4. *Medium in digestible protein and high in digestible carbodrates.*

   Wheat middlings, mixed (wheat) feed, red dog flour, gluten feeds, distillers' dried grains, pea meal, (70-87 percent digestible).

5. *High in digestible protein, medium in digestible carbohydrates.*

Cottonseed and linseed meals, (74-90 per cent digestible).

In general it may be said of the roughages that while the mainstay of farm crops for cattle feeding must be of class 1, yet class 2 should be grown and used to the limit of profit.

Of concentrates it may be said that class 1 should never be bought; that some of the feeds listed in class 2 are well worth growing, but their purchase for the purpose of feeding dairy cows is apt to be of doubtful advisability; that classes 3, 4 and 5 contain feeds which are often well worth purchasing, and that in general 5 is more desirable than 4, if not used in too great amounts, and 4 more than 3.

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[1] Wheat screenings, 62.

2. RATION MAKING

What combinations may be made of roughages and concentrates for the sundry feeding operations of the farm? Their number is legion. They vary with differences in farms, localities, animals, and their appetites; and farm and market supplies vary. It were wise for the feeder who desires information on this point to consult some good book on feeding. As to dairy feeding, however, a few general statements may be made. Nearly or quite two-thirds of the total dry matter of a ration should be fed in the form of roughages. Succulent food—silage, pasture feeding, soiling crops, roots—is to be preferred for part of the ration to all dry feed. In making up a grain ration, overfeeding with the highly concentrated feeds should be avoided. Sickness and deteriorated product may, and waste of food surely will, ensue. While phenomenal cows have handled 12 or 15 pounds of cottonseed meal a day, but few cows can safely take more than 3 pounds, and less than this is safer. It is well to err at first by using too little rather than by using too much cottonseed meal.

In combining roughages and concentrates for the production of balanced rations, much must be left to judgment. From one-fifth to one-fourth of the coarse fodder fed to cows may be made up of straw if necessary, but the intrinsic value of this farm byproduct in dairy feeding is doubtless less than it was formerly held to be. More than 15 pounds roots daily, if such be fed at all, may prove inadvisable. Thirty-five pounds of silage daily is usually a maximum. Not more than one-half of the dry matter of the roughage should be of leguminous origin. As a broad and general rule from 1 to 1.7 pounds of digestible protein should be furnished by the roughage if possible, the remainder by the grain.

Protein requirements may be met, and in some cases more than met, by feeding 6 to 8 pounds daily of a ration containing one part each of any of the concentrates mentioned on the preceding page in classes 2, 4 and 5, or in classes 3, 4 and 5, or in 2 and 5, or one part of any mentioned in class 5 combined with one and one-half parts of any mentioned in class 3. There is much range of choice which will be governed by sundry considerations already mentioned. (See bulletin 144, pages 34 to 44, for detailed statements as to ration making and for a great many suggestions as to grain rations).

3. FERTILIZING VALUE OF FODDERS AND FEEDS

The animal food content of a fodder or feed is the prime consideration in stock feeding. If, however, stock feeding is considered in its true relationship to the entire farm enterprise, as an integral part thereof and not as a matter by itself, the plant food content of cattle feeds becomes a thing of great importance. This fact, still unrecognized by the generality of western farmers, is thoroughly appreciated in the east and needs no advocacy here. While the general proposition is agreed to, the relationship of the sundry fodders and feeds to the quality of the manure is not so clear to many farmers. An animal voids nothing that it does not eat or drink; and its voidings are of a different quality, so far as plant food is concerned, in proportion to the variations in the food eaten. Rich food makes rich manure and poor food, poor manure. Clover hay, cottonseed and linseed meals, gluten feed, bran, distillery and brewery byproducts, etc., are of distinct value in this respect, while corn meal and the like rank relatively low. Table II in the appendix shows something of the manurial values of various fodders and feeds. It should not be supposed that every particle of the plant food contents of a feed of necessity reach the soil. More or less will become available to plant growth according to the care or lack of care with which the manure is handled. It is fair to assume, however, that the losses will be proportional, regardless of the quality of the manure. To the farmer who carefully observes the well known methods of preserving manure from fermentation and leaching, this table is of importance. To him who does not try to follow modern methods in this respect, it has much less value.

4. SALES AND PURCHASES

What shall the feeder grow? What shall he sell? What shall he buy? To answer these questions in all their details would require the writing of a book. A few general rules may be cited, however, leaving their application to the individual feeder?

Sales.—Nitrogen, phosphoric acid and potash are the very essence of real estate. They come from the soil, and their sale in hay, grain, milk, live stock, etc., makes drafts upon the stock of plant food of the farm. If these are not made good by supplies from without, obtained by growing legumes (clover, peas, beans, etc.), thus fixing in the soil nitrogen from the air, or by the judicious choice of purchased feeds, the depletion of the more readily available soil ingredients will ultimately ensue. Thorough tillage and cultivation will postpone but cannot prevent this ultimate result.

Carbon, hydrogen and oxygen come from the air. No outlay is needed to obtain them, and their sale does not in the least lessen the opportunity to get more. The supply is inexhaustible and free to all. Hence the sale of farm products containing relatively little nitrogen, phosphoric acid and potash, and consisting entirely, or nearly so, of carbon, hydrogen and oxygen, is an advisable procedure. Fat and water are made up entirely of these latter elements. Hence the more fat and water the farmer can sell at a profit the better, as he does not lessen his farm manurial supplies.

It often happens that sales of nitrogen, phosphoric acid and potash, disguised in the form of hay, of grain, of milk, or of live stock, are both advisable and profitable. The effect upon the farm stock of fertility should be appreciated, however, and effort made to replace the lost plant food through judicious purchases, thorough tillage, growth of legumes, etc.

Growth.—Water, carbohydrates and protein must all be grown. All are needed, whether crops are destined for market or for feeding. Choices will vary in accordance with the class of farming.

What summer and what winter roughages are advisable to grow for dairy feeding? And what are not desirable? And why? This is to some extent a matter of personal judgment. The writer is quite willing to allow anyone to disagree with him as to what is the best policy.

Summer. Soiling crops.—A succession of soiling crops designed to help out a short or a drying pasture has been proposed. Anything is better than nothing. Of the many soiling crops the writer considers weekly sowings of oats and peas, with a change to barley and peas later in the season, best adapted to Vermont conditions. Silage kept in a small surfaced, deep silo is cheaper and quite as desirable. Rowen, clover and the like may be used. Green corn, however, is expensive, as compared with silage and less serviceable.

Winter.—Hay containing much timothy sells well, and on this account, and because it is less well adapted than other grasses to dairy feeding, it is an expensive feed for cows. Clover hay and early cut hay are better adapted to this purpose. Mature corn well eared, the kernels just glazing, ensiled ears and all, makes the cheapest carbohydrate food on most Vermont farms. It need not be cut, or hurried in with extra help, but may be put in as rapidly or as slowly as circumstances may dictate. If corn is stooked or husked, the waste of nutrients is usually greater and the actual cost of handling as a rule larger than when the crop is ensiled. To be sure the work is more distributed, and less outside labor needs be hired. But in the long run the silage outclasses the dry forage. The digestible dry matter of the nutrients in the ear is not bettered for dairy purposes by husking and grinding. Immature corn is relatively watery and tends to make poor silage. It may under some circumstances be advisable to sow it very thickly, making essentially a corn hay, but it is doubtful whether this practise is generally wise in this section. Roots are a relatively costly source of food, good but expensive as compared with silage.[1] Late cut hay, for cows, is not as good as when cut early, because of its decreased digestibility.

Purchases.—The course to be pursued in buying should be the exact reverse of that employed in selling. Other things being equal, nitrogen, phosphoric acid and potash and not carbon, hydrogen and oxygen should be bought. The tables in the appendix will serve to show how ill-adapted as a supplement to farm grown food or to manurial resources is corn meal, which is bought by Vermont farmers perhaps more largely than is any other feeding stuff.

The dairy farmer in this latitude and section of the country can rarely raise protein enough to enable him to feed his cows a balanced ration, if he has worked his farm as it should be worked in the growing of carbohydrates. This is true even though hay is cut early and clover largely grown. Hence while the farm is worked as a carbohydrate factory, the feed store when resorted to should supply relatively much protein and comparatively small amounts of carbohydrates.

The three reasons on which this statement is based, are as follows:

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[1] See, however, in this connection N. Y. (Cornell) Sta. Buls. 243 (1906) on "Root Crops for Stock Feeding," and 268 (1909) on "The Substitution of Roots for Concentrated Foods in Rations for Milk Production," wherein it is contended that mangels may be raised at $4 and substituted to advantage for one-half the grain usually fed.

1. Carbohydrates are grown upon the farm with relative ease, but it is difficult to grow an amount of protein sufficient to feed a large number of animals and to balance the ration.

2. The byproducts of several industries are notably rich in protein. Hence it is sometimes cheaper to buy this nutrient than it is to raise it.

3. It is usually the best economy to endeavor to grow carbohydrates in as large amounts as possible, and to buy protein in order to supplement this growth, thus properly balancing the ration, provided the class of cows to which the ration is fed are of the proper grade.

Grain feeds.—What concentrates (grain feed) are advisable for dairy feeding and what are undesirable? And why?

Any saleable grain is worthy of consideration for growing. Corn, if husked at all, may well be ground, cob and all. Most farm-grown grains are expensive as cow feed if saleable at fair prices. It should be remembered that in buying the sundry byproducts the protein content is the prime consideration, with other matters important but secondary. The buyer will usually get better service for the same expenditure from the wheat offals and the oil and glucose byproducts (cottonseed, linseed, gluten) than from corn meal, ready ground "provenders," oat feeds, molasses feeds and the several prepared "feeds," which afford relatively expensive protein. In this connection the effects of sundry byproducts on animal and ration should be borne in mind. Cottonseed meal is rich, and, if fed in more than moderate amounts, it may cause indigestion, garget, constipation, etc. It is death to pigs and tends to harden butter. Linseed is entirely safe, laxative, and softens butter decidedly. Gluten resembles cottonseed in general effects but to a less degree, and is safe for swine. No rule can be laid down as to the amounts which may be fed with safety. The writer thinks it wise to use two rather than one of these byproducts that ill effects may be more surely minimized. These feeds should be used sparingly at the outset until the digestive capabilities of the animal are gauged. The wheat offals and distillery and brewery byproducts are, so far as is known, without effect for ill on animal or product. (See also in this connection bulletin 144, pages 22 to 34).

Economics must needs be practiced in these days of high prices; but cheapness, even the cheapest protein, is not the only thing to be considered. The greatest efficiency at the least cost should be the aim; and efficiency is measured by the milk pail, by palatability, by the effect on the product—as for instance in hardening or softening the butter—by the effect on the health ot the animal, and on the manure pile. The successful feeder must study and practice economy, have wide experience in cattle feeding, possess thorough knowledge of the effects of sundry feeds on animal and product, and finally, exercise his judgment as to adaptability of feeds to profit; and, if the latter is intelligently applied, "the greatest of these" is judgment.

VII. APPENDIX

1. Glossary of terms used in this bulletin. (Pages 591-596). Italicized words in definitions are themselves defined in the glossary thus enabling perhaps its reader the more readily to grasp an otherwise obscure definition.

2. Table I. Feeding standards. (Pages 597-599).

3. Table II. Average composition—as food and as fertilizer—of American feeding stuffs most commonly used in New England cattle feeding. (Pages 600-602).

4. Table III. American digestion coefficients and digestible ingredients in American feeding stuffs. (Pages 603-605).

4. Table IV. Pounds of total dry matter and of digestible ingredients (protein and carbohydrates—including ether extract ×2.25)—in varying weights of fodders and feeds, being essentially a convenience table. (Pages 606-611).

I. GLOSSARY OF TERMS USED IN THIS BULLETIN

ACID SOIL.—A sour soil; one showing acidity to litmus paper. Due to many causes and, as a rule, an undesirable condition.

AERATION.—The supplying with, or the charging of a body with, air; the outcome following an ample exposure to air.

ALBUMEN.—A *nitrogenous* constituent of animal and vegetable life. Its type in animal life is the white of the egg; in vegetable life it is found more particularly in the seed and in connection with the embryo.

ALBUMINOIDS.—One of the *nutrients* in the *protein* group; contains *nitrogen;* is a "flesh former"; the gluten of grains, white of egg, dry lean meat and curd of milk are albuminoids. (See page 537).

ALIMENTARY CANAL.—The entire passage from the mouth to the anus in which the food is received, digested and assimilated.

ALKALOIDS.—Alkali-like ingredients of certain plants; poisonous or narcotic; not found to any extent in normal fodders and feeds.

AMID.—One of the nitrogenous constituents of plants; a soluble form of nitrogenous matter, diffusible, capable of passing through membranes. Presumably the form in which nitrogenous matters are transferred within the plant tissues; hence they are essentially *albuminoids* in process of transportation and transition. Present in immature plants, silage, etc., in considerable quantities; of less nutritive value than true *albuminoids.*

AMINE.—A nitrogenous plant constituent akin to the *amid* in function, but chemically somewhat unlike it. See *amid.*

ANALYSIS.—The process whereby the composition or ingredients of a material are determined. Also the result of such process.

ANIMAL NUTRITION.—See nutrition.

ASH, CRUDE.—The mineral matter; the material left after complete burning; composed mainly of *potash*, soda, *lime*, magnesia, iron, sulphuric and *phosphoric acids*. (See page 538).

BACTERIA—Low forms of plant life consisting of single *cells* of *protoplasm*, microscopic in size, swarming in the soil, water, and throughout nature. They are important factors in fertilization and in soil formation. (See bulletin 130, page 219).

BYPRODUCT.—A secondary product of an industry; for instance, cottonseed meal is a byproduct of the cotton oil industry, and skimmilk and buttermilk are byproducts of butter making.

CAPILLARY WATER.—That which rises through the pores of the soil to or towards the surface by capillary attraction, as oil does in a lampwick.

CASEIN.—An *albuminoid*, a principal ingredient of milk, containing *nitrogen*. The peculiar and essential constituent which, with water and fat, constitutes cheese.

CARBOHYDRATES.—Bodies containing definite proportions of *carbon*, *hydrogen* and *oxygen*, the latter two in the proportions in which they exist in water; hence their name carbo (carbon), hydrate (water). In fodders and feeds, *cellulose* (crude fiber or woody fiber) *starch*, sugars, gums, etc., are carbohydrates.

CARBON.—A chemical element; with the elements of water makes up the larger part of the *dry matter* of plants and animals; derived from the air. Diamonds, lampblack and graphite are pure carbons; charcoal and anthracite coal are impure carbons.

CARBONIC ACID GAS.—A gas arising from the combustion of coal or wood; or from the action of acid on limestone rock. A common constituent of the air; used by plant life in building *starch* and other bodies; a combination of *carbon* and *oxygen*. The gas which appears in the common soda water of the druggist is carbonic acid gas.

CELL.—The smallest living unit of the animal or plant body. It consists essentially of *protoplasm* with a denser central mass (nucleus) and is generally enveloped by a membrane or wall. A blood corpuscle is a cell.

CELL WALL.—The subdivision walls between the myriads of cells or individual structures which make up the stalk, leaf, fruit or other parts of the plant structure.

CELLULOSE.—The substance which makes up most of the *cell wall* and other fibrous matter in the younger parts of plants. Later, much of this hardens into wood. Cotton fiber is an almost pure cellulose.

CHLOROPHYLL.—The green coloring matter of plants.

CONCENTRATE (as applied to stock feeding). Grain feed or by-product.

CONVENIENCE TABLE.—Table IV in this bulletin, which does away with a large part of the figuring needed in calculating rations.

CRUDE FIBER.—An impure *cellulose*.

CRUDE NUTRIENT.—(See nutrient).

DIGESTIBLE.—Capable of being digested.

DIGESTION COEFFICIENT.—A number expressing the percentage of a given *nutrient* which is digestible.

DIGESTION COEFFICIENTS.—(See page 554).

DRY MATTER.—(See page 539).

ECONOMIC.—Bearing on material resources; having relation to practical matters.

ELEMENT.—A form of matter indivisible by any known means into unlike parts.

ENERGY.—Force either in action or latent; a product of muscle and nerve force, but a result of the assimilation of food. There are also several physical forms of energy, i. e., heat, electricity.

ENSILE (verb).—To place a green crop for preservation in a silo.

ENZYM.—An unorganized or chemical *ferment* of animal or of vegetable origin: e. g., pepsin (from the animal stomach), diastase (*starch* digester from malted barley), etc. *Bacterial* effects are largely enzymic in their nature, being brought about through the action of the enzyms they secrete.

ETHER EXTRACT.—(See page 539).

EXCRETA.—Voidings, as *feces*, urine, perspiration, the exhaled breath in animal life; or *oxygen*, water vapor, etc., in plant life.

EXTRACT MATTER.—(See nitrogen-free extract).

EXTRACTIVE MATTER.—A stimulative nitrogenous material in flesh; the main constituent of beef tea, meat extracts, etc. (See page 537).

FAT.—A combination of fatty acids with glycerin; the main part of the *ether extract* of seeds and grains; a common constituent of the animal body. Crude fat is a synonym for *ether extract*, which see.

FECES.—The voidings of the animal intestine.

FEEDING STANDARD.—A numerical expression of the proportion of sundry digestible *nutrients* best adapted to some specific end, the same being deduced from experiment, or practice, or both. (See pages 557 and following).

FERMENT.—A substance, *organic* or *inorganic*, living or the product of life action, or in some cases of mineral origin, which is capable of producing *fermentation*.

FERMENTATION.—A chemical decomposition of an organic compound, due to living organisms, or, rather, to their secretions (*enzyms*), or to chemical or enzymic agencies. There are multitudinous fermentations.

FODDER.—A natural combination of *nutrients*.

FUEL VALUE.—The degrees of temperature rise caused by the burning of a definite weight of a given substance; used as a measure of food values.

GELATINOIDS.—Animal *proteins* of a gelatinous nature. (See page 537).

GERMAN STANDARD.—See Wolff standard.

GUMS.—Materials of a *carbohydrate* nature and of a tenaceous character.

HUMUS.—A black or brownish soil ingredient, the resultant of vegetable decay; vegetable mold. Vegetable matter decaying is not humus; vegetable matter decayed is humus. (See bulletin 135).

HYDROGEN.—A chemical element, a gas, the lightest known substance; combined with *oxygen* it forms water; with oxygen and carbon it forms *carbohydrates* and *fat;* with these and *nitrogenous*, sulphur and phosphorus, it forms the many complex *organic* nitrogenous bodies.

INSALIVATION.—The mixing of saliva with food in the act of chewing.

LEGUMES.—Plants bearing seeds in pods, and capable of fixing *nitrogen* from the air; clovers, peas, beans, vetches, etc.

LIGNIN.—A constituent of *crude fiber*, essentially the woody cells of the plant fibers.

LIME.—Strictly a combination of calcium and *oxygen;* quicklime. Commonly used also for slaked lime (calcium, *oxygen*, water, etc.). (See bulletin 99 for discussion).

MARSH GAS (Methane).—*Carbon* and *hydrogen* in the proportion of 1 to 4. A gas formed over marshes, the product of *bacterial* action causing the decay of vegetable matter; the product of certain forms of intestinal *bacteria* acting on the *cellulose* or *crude fiber* of the food.

MASTICATION.—The act of crushing or grinding food by the teeth prior to its being swallowed.

METABOLISM.—The constructive processes whereby food is built into living tissue; also the destructive ones whereby living tissue is resolved to simpler compounds fit only to be voided. The former is the work of digestion, assimilation, circulation; the latter, of excretion.

MOLECULE.—The smallest part of a compound substance capable of separate existence without modification of its properties.

NEUTRAL.—Neither *acid* nor *alkaline*.

NITRATES.—Combinations of nitric acid with elements like *lime*, soda, *potash*, etc.

NITROGEN.—An element, an inert gas; the central element, so to speak of *protein;* the most costly element in common use in agriculture.

NITROGEN-FREE EXTRACT.—(See page 539).

NITROGENOUS MATTER.—Substances containing nitrogen. (See page 537).

NON-FATTY ETHER EXTRACT.—Material extracted from sundry fodders or feeds by ether which are not fatty in their character, including usually *gums*, resins, *chlorophyll*, etc.

NON-PROTEIDS.—Nitrogenous materials not *proteid* in their character; consisting in the animal economy of the *gelatinoids* (gristle, hoofs, horns) or *extractives* (beef tea); consisting in vegetable life more particularly of the *amines*, *amids*, *nitrates*, *alkaloids*, etc.

NUTRIENT.—"Crude nutrient" is a synonym for total ingredient; for instance, the total *ether extract* in a *fodder* is a crude nutrient. "Digestible nutrient" is a synonym for nutrient and indicates solely that portion of the crude nutrient which is digestible. (See page —).

NUTRITION, ANIMAL.—The process of promoting growth, or of replacing waste of the animal tissues.

NUTRITIVE RATIO.—(See page 539).

ORGANIC MATTER.—(See page 539).

ORGANISM.—An *organized* living being, either plant or animal, so called because of its organized structure.

OXIDATION.—The addition of *oxygen* to a metal or compound. Rusted iron is oxidized iron.

OXYGEN.—The most common element in nature, a colorless, tasteless, odorless but active gas; one-fifth of the air, eight-ninths of water by weight is oxygen.

PALATABILITY.—The quality which makes a material agreeable to the taste. It has no necessary relation to *digestibility;* a food may be palatable yet indigestible, or digestible but distasteful.

PECTIN.—A constituent of fodders and feeds found in various fresh fruits, such as apples, and in roots, such as carrots, turnips, etc. Pectin is the basis of jellies.

PENTOSAN.—A constituent of the *nitrogen-free-extract-matter* of fodders and feeds; usually less digestible and serviceable in nutrition than are the *starches*, *sugars*, etc.

PERCOLATION.—The downward passage of water through the soil and the sub-soil to the drainage waters.

PHOSPHATE OF LIME.—A combination of *phosphoric acid* and *lime;* a prominent constituent of bones, *ash*, etc.

PHOSPHORIC ACID.—A compound of phosphorus, *oxygen* and *hydrogen*, important both as plant and animal food; in the latter case it is usually combined with *lime* as *phosphate of lime*.

PHYSIOLOGICAL STANDARD.—One based on knowledge of the functions of the class of animals to be fed.

POTASH.—A compound of the elements of potassium and *oxygen*, important as plant food.

PROTEIDS.—Important animal and vegetable compounds of great complexity, *nitrogen* being the characteristic element. No life phenomena, animal or vegetable, proceeds without involving proteids. Flesh tissue is proteid in its nature. (See protein).

PROTEIN, CRUDE.—The principal *nitrogen-containing* substances of fodders and feeds. (See page 537).

PROTOPLASM.—The substance which constitutes the living portion of an animal or a vegetable *cell*. Therefore called by Huxley "the physical basis of life."

RATION.—An artificial mixture of *fodders*, or of *fodders* and feeds.

RESPIRATION CALORIMETER.—A complicated device used in the determination of food values, wherein an animal is confined, and its income and outgo measured in terms of food and divers excreta, also in terms of *energy* consumed in the food and emitted in the evolved heat. The most modern and exact instrument used in the determination of ultimate food values.

ROUGHAGE.—Coarse *fodders* (hay, corn fodder, silage, roots, etc.,) as distinguished from grains, etc.

RUMINANT.—An animal which chews its cud or ruminates. The term is derived from the first so-called stomach or rumen, from which the food, after being swallowed, is thrown back again into the mouth for further chewing and mixing with saliva.

SOLUTION.—A liquid combination of a liquid and non-liquid substance. The change of matter from a solid or gaseous into a liquid state through its combination with liquid. Exactly what happens when a salt passes into solution is still a vexed question.

STARCH.—One of the most common *carbohydrates* in *fodders* and feeds, insoluble in water but digestible, being transformed into *sugar* during digestion.

SUGARS.—Sweet compounds of vegetable and animal origin; *carbohydrates* much like *starch* chemically, but soluble in water.

TOTAL DRY MATTER.—(See dry matter).

TRANSPIRATION.—The process whereby water is thrown off from the leaves, this being the main source of the exit of water from the plant.

WOLFF AND WOLFF-LEHMANN STANDARDS. (See pages 557 and following).

TABLE I. FEEDING STANDARDS

(Showing amounts of nutrients for a day's feeding)

Animal	Total dry matter	Digestible protein	Digestible carbohydrates and fat†	Total digestible nutrients†	Nutritive ratio
	lbs.	lbs.	lbs.	lbs.	
Cow	*24.	2.5	13.4	15.9	1: 5.4
Oxen					
At rest in stall	18.	0.7	8.2	8.9	1:11.8
At light work	22.	1.4	10.7	12.1	1: 7.7
At medium work	25.	2.0	12.6	14.6	1: 6.5
At heavy work	28.	2.8	14.8	17.6	1: 5.3
Fattening cattle					
First period	30.	2.5	16.1	18.6	1: 6.5
Second period	30.	3.0	16.1	19.1	1: 5.4
Third period	26.	2.7	16.6	19.3	1: 6.2
Milch cows					
When yielding daily—					
11.0 pounds of milk	25.	1.6	10.7	12.3	1: 6.7
16.6 pounds of milk	27.	2.0	11.9	13.9	1: 6.0
22.0 pounds of milk	29.	2.5	14.1	16.6	1: 5.7
27.5 pounds of milk	32.	3.3	14.8	18.1	1: 4.5
Sheep					
Coarse wool	20.	1.2	11.0	12.2	1: 9.1
Fine wool	23.	1.5	12.7	14.2	1: 8.5
Breeding ewes					
With lambs	25.	2.9	16.1	19.0	1: 5.6
Fattening sheep					
First period	30.	3.0	16.1	19.1	1: 5.4
Second period	28.	3.5	15.9	19.4	1: 4.5
Horses					
Light work	20.	1.5	10.4	11.9	1: 7.0
Medium work	24.	2.0	12.3	14.3	1: 6.2
Heavy work	26.	2.5	15.1	17.6	1: 6.0
Brood sows	22.	2.5	16.4	18.9	1: 6.6
Fattening swine					
First period	36.	4.5	26.6	31.1	1: 5.0
Second period	32.	4.0	25.1	29.1	1: 6.9
Third period	25.	2.7	18.9	21.6	1: 7.3

*Total organic matter.
†Fat × 2¼.

TABLE I. FEEDING STANDARDS—*Continued*

(Showing amounts of nutrients for a day's feeding)

Animal	Total dry matter	Digestible protein	Digestible carbohydrates and fat†	Total digestible nutrients†	Nutritive ratio
	lbs.	lbs.	lbs.	lbs.	
***Growing cattle* (dairy breeds)**					
2- 3 mos. 150 lbs.	23.	4.0	17.5	21.5	1: 4.5
3- 6 mos. 300 lbs.	24.	3.0	15.1	18.1	1: 5.1
6-12 mos. 500 lbs.	27.	2.0	13.6	15.6	1: 6.8
12-18 mos. 700 lbs.	26.	1.8	13.4	15.2	1: 7.5
18-24 mos. 900 lbs.	26.	1.5	12.7	14.2	1: 8.5
***Growing cattle* (beef breeds)**					
2- 3 mos. 160 lbs.	23.	4.2	17.5	21.7	1: 4.2
3- 6 mos. 330 lbs.	24.	3.5	16.2	19.7	1: 4.7
6-12 mos. 550 lbs.	25.	2.5	14.8	17.3	1: 6.0
12-18 mos. 750 lbs.	24.	2.0	13.6	15.6	1: 6.8
18-24 mos. 950 lbs.	24.	1.8	12.9	14.7	1: 7.2
***Growing sheep* (wool breeds)**					
4- 6 mos. 60 lbs.	25.	3.4	17.0	20.4	1: 5.0
6- 8 mos. 75 lbs.	25.	2.8	15.2	18.0	1: 5.4
8-11 mos. 80 lbs.	23.	2.1	12.6	14.7	1: 6.0
11-15 mos. 90 lbs.	22.	1.8	12.1	13.9	1: 7.0
15-20 mos. 100 lbs.	22.	1.5	11.5	13.0	1: 7.7
***Growing sheep* (mutton breeds)**					
4- 6 mos. 60 lbs.	26.	4.4	17.5	21.9	1: 4.0
6- 8 mos. 80 lbs.	26.	3.5	16.6	20.1	1: 4.8
8-11 mos. 100 lbs.	24.	3.0	15.4	18.4	1: 5.2
11-15 mos. 120 lbs.	23.	2.2	13.7	15.9	1: 6.3
15-20 mos. 150 lbs.	22.	2.0	12.9	14.9	1: 6.5
***Growing swine* (breeding stock)**					
2- 3 mos. 50 lbs.	44.	7.6	30.3	37.9	1: 4.0
3- 5 mos. 100 lbs.	35.	5.0	24.9	29.9	1: 5.0
5- 6 mos. 120 lbs.	32.	3.7	22.2	25.9	1: 6.0
6- 8 mos. 200 lbs.	28.	2.8	19.4	22.2	1: 7.0
8-12 mos. 250 lbs.	25.	2.1	15.8	17.9	1: 7.5

†Fat × 2¼.

TABLE I. FEEDING STANDARDS—*Concluded*

(Showing amounts of nutrients for a day's feeding)

Animal	Total dry matter	Digestible protein	Digestible carbohydrates and fat†	Total digestible nutrients†	Nutritive ratio
	lbs.	lbs.	lbs.	lbs.	
Growing fattening swine					
2- 3 mos. 50 lbs.	44.	7.6	30.2	37.8	1: 4.0
3- 5 mos. 100 lbs.	35.	5.0	24.9	29.9	1: 5.0
5- 6 mos. 150 lbs.	33.	4.3	23.7	28.0	1: 5.5
6- 8 mos. 200 lbs.	30.	3.6	21.4	25.0	1: 6.0
9-12 mos. 200 lbs.	26.	3.0	19.0	22.0	1: 6.4
Cow (700-950 lbs.) giving					
10-20 lbs. milk	21.	2.0	11.9	13.9	1: 6.0
20-25 "	22.	2.3	12.1	14.4	1: 5.3
25-30 "	22.	2.6	12.1	14.7	1: 4.7
30-35 "	23.	2.9	13.4	16.3	1: 4.6
35-40 "	23.	3.2	13.4	16.6	1: 4.2
Cow (950-1100 lbs.) giving					
10-20 lbs. milk	23.	2.3	14.1	16.4	1: 6.1
20-25 "	24.	2.6	14.2	16.8	1: 5.5
25-30 "	24.	2.9	14.2	17.1	1: 5.1
30-35 "	25.	3.2	15.6	18.8	1: 4.9
35-40 "	25.	3.5	15.6	19.1	1: 4.4
Cow (128 herds)	24.5	2.2	15.0	17.2	1: 6.9
" (32 herds) (1000 lbs.)	26.5	2.0	13.2	15.2	1: 7.0
" (1 herd) (1000 lbs.)	23.5	2.1	14.5	16.6	1: 7.1
" (1 herd) (1400 lbs.)	22.	1.9	13.8	15.7	1: 7.2
" (1 herd) dry cows	15.	1.1	9.3	10.4	1: 8.5

†Fat × 2¼.

NOTE.—The standards on pages 597 (save the first) and 598 and all but the last five on this page are the Wolff-Lehmann standards. The first on page 597 is the original Wolff standard for cows; the 128 herd standard, the so-called Wisconsin standard; the 32 herd, one proposed by the Connecticut (Storrs) station; the last three are suggested by the Michigan station.

TABLE II. AVERAGE COMPOSITION OF FEEDING STUFFS MOST COMMONLY USED IN NEW ENGLAND CATTLE FEEDING

FODDERS	Number of analyses	Food constituents						Fertilizing ingredients		
		Water	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
ROUGHAGES										
Fresh grass, cereals, green corn forage, fresh legumes		%	%	%	%	%	%	%	%	%
Pasture grass	..	80.0	2.0	3.5	4.0	9.7	0.8	0.91	0.23	0.75
Timothy (different stages)...	56	61.6	2.1	3.1	11.8	20.2	1.2	0.48	0.26	0.76
Red top (in bloom)........	5	65.3	2.8	2.8	11.0	17.7	0.9	0.45	....	....
Kentucky blue grass (June grass)	18	65.1	2.8	4.1	9.1	17.6	1.3	0.66	0.24	1.08
Orchard grass (in bloom)...	4	78.0	2.0	2.6	8.2	13.8	0.9	0.43	0.16	0.76
Rowen	4	70.1	2.4	4.5	7.6	13.7	1.7	0.72	0.15	0.55
Hungarian	14	71.1	1.7	3.1	9.2	14.2	0.7	0.39	0.16	0.55
Japanese millet	12	75.0	1.5	2.1	7.8	13.1	0.5	0.33	0.10	0.22
Barn yard millet	2	75.0	1.9	2.4	7.0	13.1	0.6	0.30	0.10	0.67
Barley fodder	6	75.2	2.0	3.4	6.5	12.0	0.9	0.54	....	....
Oat fodder	5	62.2	2.5	3.4	11.2	19.3	1.4	0.49	0.13	0.38
Rye fodder	7	76.6	1.8	2.6	11.6	6.8	0.6	0.33	0.15	0.73
Oats and peas	9	78.7	1.7	3.5	6.0	9.1	1.0	0.56	0.12	0.54
Barley and peas	9	79.4	1.8	3.7	5.2	9.1	0.8	0.59	....	....
Fodder corn	126	79.3	1.2	1.8	5.0	12.2	0.5	0.41	0.15	0.33
Dent corn	63	79.0	1.2	1.7	5.6	12.0	0.5	....	....	....
Dent corn (kernels glazed)..	7	73.4	1.5	2.0	6.7	15.5	0.9	....	....	....
Flint corn	40	79.8	1.1	2.0	4.3	12.1	0.7	....	....	....
Flint corn (kernels glazed)..	10	77.1	1.1	2.7	4.3	14.6	0.8	....	....	....
Sweet corn	21	79.1	1.3	1.9	4.4	12.8	0.5	....	....	....
Red clover (different stages).	43	70.8	2.1	4.4	8.1	13.5	1.1	0.53	0.13	0.46
Alsike clover	4	74.8	2.0	3.9	7.4	11.0	0.9	0.44	0.11	0.20
Clover rowen	5	75.0	2.1	4.6	6.2	11.0	1.1	0.74	....	....
Canada field peas	8	85.0	1.3	3.2	4.3	5.8	0.4	0.5	0.12	0.38
Alfalfa	23	71.8	2.7	4.8	7.4	12.3	1.0	0.72	0.13	0.56
Soy bean	27	75.1	2.6	4.0	6.7	10.6	1.0	0.65	0.15	0.57

TABLE II. AVERAGE COMPOSITION OF FEEDING STUFFS MOST COMMONLY USED IN NEW ENGLAND CATTLE FEEDING—*Continued*

FODDERS	Number of analyses	Food constituents						Fertilizing ingredients		
		Water	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
ROUGHAGES										
Hays from grains, cereals and legumes		%	%	%	%	%	%	%	%	%
Hay from mixed grasses	126	15.3	5.5	7.4	27.2	42.1	2.5	1.41	0.27	1.55
Timothy (all stages)	68	13.2	4.4	5.9	29.0	45.0	2.5	1.26	0.53	0.90
Timothy (cut in full bloom)	12	15.0	4.5	6.0	29.6	41.9	3.0	....	....	....
“ (cut soon after bloom)	11	14.2	4.4	5.7	28.1	44.6	3.0	....	....	....
“ (cut when nearly ripe)	12	14.1	3.9	5.0	31.1	43.7	2.2	....	....	....
Red top (different stages)	9	8.9	5.2	7.9	28.6	47.5	1.9	1.15	0.36	1.02
Kentucky blue grass (June grass)	8	26.1	6.7	6.1	24.1	33.7	3.3	1.19	0.40	1.57
Orchard grass	10	9.9	6.0	8.1	32.4	41.0	2.6	1.31	0.41	1.88
Rowen (mixed)	23	16.6	6.8	11.6	22.5	39.4	3.1	1.61	0.43	1.49
Rowen (fine)	15	13.1	6.5	14.0	24.4	38.3	3.7	2.24	....	....
Hungarian	33	16.5	5.6	8.2	22.6	43.9	3.2	1.20	0.35	1.30
Barley hay (cut in milk)	1	15.0	4.2	8.8	24.7	44.9	2.4	....	....	....
Oat hay (cut in milk)	1	15.0	5.2	9.3	29.2	39.0	2.3	....	....	....
Oat hay	6	8.9	6.2	7.6	29.3	45.1	2.9	1.22	0.50	0.80
Oat and pea hay	8	11.5	6.6	14.8	24.9	38.9	3.3	2.37	0.54	2.25
Barley straw	97	14.2	5.7	3.5	36.0	39.0	1.5	0.56	0.30	2.09
Oat straw	12	9.2	5.1	4.0	37.0	42.4	2.3	0.62	0.20	1.24
Wheat straw	7	9.6	4.2	3.4	38.1	43.4	1.3	0.59	0.12	0.51
Rye straw	7	7.1	3.2	3.0	38.9	46.6	1.2	0.46	0.28	0.79
Corn fodder (field cured)	35	42.2	2.7	4.5	14.3	34.7	1.6	1.76	0.54	0.89
Corn stover (field cured)	60	40.1	3.4	3.8	19.8	31.8	1.1	1.04	0.29	1.40
Mixed grasses and clover	17	12.9	5.5	10.1	27.6	41.3	2.6	....	....	....
Red clover hay	38	15.3	6.2	12.3	24.8	38.1	3.3	2.07	0.38	2.20
“ (in bloom)	6	20.8	6.6	12.4	21.9	33.8	4.5	....	....	....
“ (mammoth)	10	21.2	6.1	10.7	24.5	33.6	3.9	2.23	0.55	1.22
Alsike clover hay	9	9.7	8.3	12.8	25.6	40.7	2.9	2.34	0.67	2.23
Clover rowen hay	1	8.3	7.1	13.1	31.3	37.9	2.3	2.10	....	....
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7	2.2	2.19	0.51	1.68
Soy bean	6	11.3	7.2	15.4	22.3	38.6	5.2	....	....	....
Silages, roots, etc.										
Corn silage (mature corn)	49	73.7	1.6	2.2	6.5	15.1	0.9	0.35	0.10	0.40
“ (immature corn)	99	79.1	1.4	1.7	6.0	11.0	0.8	0.27	0.11	0.37
Corn stover silage (ears plucked off)	6	80.7	1.8	1.8	5.6	9.5	0.6	0.29	0.11	0.45
Corn and soy bean silage	4	76.0	2.4	2.5	7.2	11.1	0.8	0.65	0.35	0.36
Rye silage	1	80.8	1.6	2.4	5.8	9.2	0.3	....	....	....
Red clover silage	5	72.0	2.6	4.2	8.4	11.6	1.2	0.67	....	....
Apple pomace silage	4	79.7	1.0	1.6	4.3	12.0	1.4	0.28	0.09	0.24
Potatoes	12	78.9	1.0	2.1	0.6	17.3	0.1	0.32	0.12	0.46
Beets	9	88.5	1.0	1.5	0.9	8.0	0.1	0.24	0.09	0.44
Sugar beets	19	86.5	0.9	1.8	0.9	9.8	0.1	0.22	0.10	0.48
Carrots	8	88.6	1.0	1.1	1.3	7.6	0.4	0.15	0.09	0.51
Mangel-wurtzels	9	90.9	1.1	1.4	0.9	5.5	0.2	0.19	0.09	0.38
Rutabagas	4	88.6	1.2	1.2	1.3	7.5	0.2	0.19	0.12	0.49
Turnips	3	90.5	0.8	1.1	1.2	6.2	0.2	0.18	0.10	0.39

TABLE II. AVERAGE COMPOSITION OF FEEDING STUFFS MOST COMMONLY USED IN NEW ENGLAND CATTLE FEEDING—*Concluded*

FODDERS	Number of analyses	Food constituents						Fertilizing ingredients		
		Water	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
ROUGHAGES										
Miscellaneous		%	%	%	%	%	%	%	%	%
Apples	3	80.7	0.4	0.7	1.2	16.6	0.4	0.11	0.01	0.19
Apple pomace	7	76.7	0.5	1.4	3.9	16.2	1.3	0.22	0.02	0.13
Pumpkins	..	90.9	0.5	1.3	1.7	5.2	0.4	0.11	0.16	0.09
Cabbage	2	90.5	1.4	2.4	1.5	3.9	0.4	0.38	0.11	0.43
Rape	2	84.5	2.0	2.3	2.6	8.4	0.5	0.45	0.15	0.36
Skimmilk	7	90.6	0.7	3.1	...	5.3	0.3	0.56	0.20	0.19
Buttermilk	85	90.1	0.7	4.0	...	4.0	1.1	0.48	0.17	0.16
Whey	46	93.8	0.4	0.6	...	5.1	0.1	0.15	0.14	0.18
Dried blood	3	8.5	4.7	84.4	...	...	2.5	13.50	1.35	0.77
Meat scrap	144	10.7	4.1	71.2	...	0.3	13.7	11.39	0.70	0.10
Meat and bone meal	37	6.0	37.4	39.5	...	6.3	10.8	....	....	....
Beet molasses	35	20.8	10.6	9.1	...	59.5	...	1.46	0.05	5.63
Porto Rico molasses	2	24.0	6.8	3.1	...	66.1	....	....	....	....
CONCENTRATES										
Grains and byproducts										
Corn meal	77	15.0	1.4	9.2	1.9	68.7	3.8	1.47	0.63	0.40
Corn and cob meal	7	15.1	1.5	8.5	6.6	64.8	3.5	1.41	0.57	0.47
Corn (dent)	86	10.6	1.5	10.3	2.2	70.4	5.0	1.65	....	....
" (flint)	68	11.3	1.4	10.5	1.7	70.1	5.0	1.68	....	....
" (sweet)	26	8.8	1.9	11.6	2.8	66.8	8.1	1.86	....	....
Corn cobs	18	10.7	1.4	2.4	30.1	54.9	0.5	....	....	....
Corn bran	5	9.1	1.3	9.0	12.7	62.2	5.8	1.63	1.21	0.68
Gluten feed	11	7.8	1.1	24.0	5.3	51.2	10.6	3.84	0.41	0.03
Hominy chops	..	8.4	2.6	11.3	4.9	64.9	7.9	1.63	0.98	0.49
Distillers' dried grains	56	8.0	1.2	31.7	12.3	34.2	12.1	5.39	0.61	0.31
Wheat	310	10.5	1.8	11.9	1.8	71.9	2.1	2.36	0.80	0.50
Wheat bran	88	11.9	5.8	15.4	9.0	53.9	4.0	2.67	2.89	1.61
" " (spring)	10	11.5	5.4	16.1	8.0	54.5	4.5	....	....	....
" " (winter)	7	12.3	5.9	16.0	8.1	53.7	4.0	....	....	....
" middlings (flour)	106	10.0	3.2	16.2	3.2	59.6	4.8	2.50	0.95	0.63
" " (standard)	308	10.0	4.3	17.9	7.0	55.8	5.0			
" screenings	10	11.6	2.9	12.5	4.9	65.1	3.0	2.44	1.17	0.84
Mixed (wheat) feed	48	10.8	5.5	16.8	7.4	54.8	4.7	2.69	2.57	1.43
Red dog flour (low grade feeding flour)	1	9.7	4.3	19.9	3.8	56.2	6.2	3.18	2.14	1.09
Rye	6	11.6	1.9	10.6	1.7	72.5	1.7	1.76	0.82	0.54
Rye bran	7	11.6	3.6	14.7	3.5	63.8	2.8	2.32	2.28	1.40
Barley	10	10.9	2.4	12.4	2.7	69.8	1.8	1.51	0.79	0.48
Barley screenings	2	12.2	3.6	12.3	7.3	61.8	2.8	1.97	....	....
Brewers' dried grains	9	10.0	3.4	23.6	12.0	45.6	5.5	3.62	1.08	0.09
Malt sprouts	4	10.2	5.7	23.2	10.7	48.5	1.7	3.55	1.43	1.63
Oats	30	11.0	3.0	11.8	9.5	59.7	5.0	2.06	0.82	0.62
Oat hulls	1	7.3	6.7	3.3	29.7	52.1	1.0	0.52	0.24	0.52
Provender (½ oat, ½ corn)	..	13.0	2.2	10.5	5.7	64.2	4.4	1.75	0.73	0.51
Buckwheat	8	12.6	2.0	10.0	8.7	64.5	2.2	1.44	0.44	0.21
Buckwheat hulls	2	11.6	2.8	5.6	35.0	48.4	1.6	0.49	0.07	0.52
Buckwheat bran	2	10.5	3.0	12.4	31.9	38.8	3.3	3.64	1.78	1.28
Buckwheat middlings	6	11.5	4.5	27.5	4.2	45.3	7.0	4.28	2.19	1.14
Cottonseed meal	35	8.2	7.2	42.3	5.6	23.6	13.1	6.79	2.88	1.87
Cottonseed hulls	20	11.1	2.8	4.2	46.3	33.4	2.2	0.69	0.25	1.02
Linseed meal (old process)	8	9.9	5.8	34.6	8.1	34.1	7.5	5.43	1.66	1.37
Linseed meal (new process)	4	10.7	5.6	38.1	8.2	34.8	2.6	5.78	1.83	1.39
Pea meal	2	10.5	2.6	20.2	14.4	51.0	11.2	3.08	0.82	0.99

TABLE III. AMERICAN DIGESTION COEFFICIENTS; DIGESTIBLE INGREDIENTS OF AMERICAN FEEDING STUFFS

FODDERS	Number of trials	Digestion coefficients						Percentage of digestible ingredients							
		Dry matter	Organic matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Dry matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Total digestible carbohydrates	Nutritive ratio (2nd term)	Protein equating factor
ROUGHAGES															
Fresh grass, cereals, green corn, forage, fresh legumes															
Pasture grass	4	71	..	70	76	73	63	14.2	2.5	3.0	7.1	0.5	11.1	4.4	40.0
Timothy	5	58	..	50	52	64	47	22.3	1.6	6.1	12.9	0.6	20.7	12.9	62.5
Red top		Assume timothy						24.6	2.0	8.4	12.9	0.6	22.7	10.9	50.0
Kentucky blue grass		Assume timothy						24.8	2.9	6.9	12.8	0.8	21.5	7.4	34.5
Orchard grass (in bloom)	1	56	..	59	51	54	51	15.1	1.5	4.2	7.2	0.5	12.5	8.3	66.7
Rowen	2	..	66	72	64	68	52	20.0	3.2	4.9	9.3	0.9	16.2	5.1	31.2
Hungarian	8	66	68	63	70	67	62	19.1	2.0	6.4	9.5	0.4	16.8	8.4	50.0
Japanese millet	3	..	64	50	62	67	68	16.0	1.1	4.8	8.8	0.3	14.8	13.0	90.9
Barnyard millet	6	70	..	65	73	71	58	17.5	1.6	5.1	9.3	0.3	15.1	9.4	62.5
Barley fodder (in bloom)	4	67	..	72	61	71	60	16.6	2.4	4.0	8.5	0.5	13.6	5.7	41.7
Oat fodder (bloom early seeded)	5	..	62	73	55	62	69	23.4	2.5	6.2	12.0	1.0	20.2	8.1	40.0
Rye fodder (heading)	2	74	..	79	80	71	74	17.3	2.1	9.3	4.8	0.4	15.0	7.1	47.6
Oats and peas (bloom and partly seeded)	10	70	65	74	60	67	64	14.9	2.6	3.6	6.1	0.6	11.1	4.3	38.5
Barley and peas	4	..	65	75	52	68	59	13.8	2.7	3.2	6.5	0.5	10.8	4.0	37.0
Dent corn (immature)	14	68	..	66	65	71	68	14.3	1.1	3.8	8.5	0.3	13.0	11.8	90.9
Dent corn (mature)	17	68	72	53	57	73	74	18.1	1.1	3.8	11.3	0.7	16.7	15.2	90.9
Flint corn	..	..	..	..	..	..	..	13.9	1.0	3.3	8.6	0.5	13.0	13.0	100.0
Flint corn (mature)	4	69	71	52	75	71	66	15.8	1.4	3.2	10.4	0.5	14.7	10.5	71.4
Sweet corn	12	..	72	62	60	77	74	15.0	1.2	2.6	9.9	0.4	13.4	11.2	83.4
Red clover (late bloom)	2	66	..	67	53	78	65	19.3	2.9	4.3	10.5	0.7	16.4	5.7	34.5
Clover rowen (late bloom)	2	61	..	62	52	65	61	15.3	2.9	3.2	7.2	0.7	12.0	4.1	39.5
Canada field peas	6	64	..	81	45	76	55	9.6	2.6	1.9	4.4	0.2	6.8	2.6	38.5
Alfalfa	2	61	..	74	43	72	39	17.2	3.6	3.2	8.9	0.4	13.0	3.6	27.8
Soy bean	18	65	66	77	45	75	54	16.2	3.1	3.0	8.0	0.5	12.1	3.9	32.3
Hays from grains, cereals and legumes															
Mixed hay	60	60	62	57	60	61	50	50.8	4.2	16.3	25.7	1.3	44.9	10.6	23.8
Timothy	58	55	56	48	50	62	50	47.8	2.8	14.5	27.9	1.3	45.3	16.2	35.7
Timothy (cut in full bloom)	8	59	58	57	57	63	48	50.2	3.4	16.9	26.4	1.4	46.5	13.7	29.4
Timothy (cut soon after bloom)	17	52	52	43	46	59	51	44.6	2.5	12.9	26.3	1.5	42.6	17.0	40.0
Timothy (cut when nearly ripe)								44.6	2.2	14.3	25.8	1.1	42.6	19.4	45.5
Red top	3	60	61	61	61	62	51	54.6	4.8	17.4	29.5	1.0	48.9	10.2	20.8
Kentucky blue grass (June grass)	1	56	..	57	63	53	43	41.4	3.5	15.1	17.9	1.4	36.3	10.4	28.6
*Witch grass (quack grass)	4	61	62	58	62	66	57	....	....	....	....	....	....	....	...
Orchard grass	3	56	56	60	61	55	55	50.5	4.9	19.8	22.6	1.4	45.6	9.3	20.4
Rowen (mixed)	12	..	65	70	66	65	47	54.2	8.1	14.9	25.6	1.5	43.9	5.4	12.3
Rowen (fine)								56.5	9.8	16.1	24.9	1.7	44.8	4.6	10.2

TABLE III. AMERICAN DIGESTION COEFFICIENTS; DIGESTIBLE INGREDIENTS OF AMERICAN FEEDING STUFFS—*Continued*

FODDERS	Number of trials	Digestion coefficients						Percentage of digestible ingredients							
		Dry matter	Organic matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Dry matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Total digestible carbohydrates	Nutritive ratio (2nd term)	Protein equating factor
ROUGHAGES															
Hungarian	2	65	66	60	68	67	64	54.3	4.9	15.4	29.4	2.1	49.5	9.1	20.4
Barley hay (cut in milk)	4	59	62	65	62	63	41	50.2	5.7	15.8	28.3	1.0	45.6	8.0	17.5
Oat hay (cut in milk)	14	54	54	52	48	56	64	45.9	4.8	14.0	21.8	1.5	39.2	8.2	20.8
Oat hay (all heads)	20	54	54	53	51	55	60	49.2	4.0	14.9	24.8	1.8	43.8	11.0	25.0
Oat and pea hay	7	61	60	73	58	61	59	54.0	10.8	14.4	23.7	1.9	42.4	39.0	9.3
Barley straw	5	53	..	20	56	54	42	45.5	0.7	20.2	21.1	0.6	43.0	61.4	142.8
Oat straw	19	48	..	30	54	44	33	43.6	1.2	20.0	18.7	0.8	40.5	33.8	83.3
Wheat straw	7	43	..	11	52	38	31	38.9	0.4	19.8	16.5	0.4	37.2	93.0	250.0
Rye straw	9	46	..	21	60	37	32	42.7	0.6	23.3	17.2	0.4	41.4	69.0	166.7
Corn fodder	41	68	..	55	70	72	71	39.3	2.5	8.0	25.0	1.2	35.7	8.9	40.0
Corn stover	31	57	55	36	64	59	67	34.2	1.4	12.7	18.8	0.7	33.1	23.6	71.4
Mixed grasses and clover	2	55	..	38	53	60	58	47.9	3.8	14.6	24.8	1.5	42.8	11.3	26.3
Red clover hay	18	57	54	58	54	64	55	48.3	7.1	13.4	24.4	1.8	41.9	5.9	14.1
Red clover hay (in bloom)	46	61	..	62	49	69	62	48.3	7.7	10.7	23.3	2.8	40.3	5.2	13.0
Red clover hay (mammoth)		Assume red clover						44.9	6.2	13.2	21.5	2.4	40.1	6.5	16.1
Alsike clover hay	9	59	60	66	50	66	38	53.3	8.4	12.8	26.9	1.1	42.2	5.0	11.9
Clover rowen hay	4	..	59	65	47	63	60	54.1	8.5	14.7	23.9	1.4	41.8	4.9	11.8
Alfalfa	39	62	..	72	47	72	43	56.8	10.3	11.8	30.7	0.9	44.5	4.3	9.8
Soy bean	2	62	..	71	61	69	29	55.0	10.9	13.6	26.6	1.5	43.6	4.0	9.1
Silage, roots, etc.															
Corn silage (mature corn) flint dent	11	75	77	65	77	79	82	17.4	1.1	4.2	10.7	0.7	16.5	15.0	90.9
Corn silage (immature corn) flint	17	64	64	53	68	66	71	13.4	0.9	4.1	7.3	0.6	12.8	14.2	111.1
Corn stover silage (ears plucked off)	..	..	..	..	..	..	..	11.0	0.6	3.6	5.5	0.4	10.0	16.7	166.7
Corn and soy bean silage	8	69	72	63	62	78	83	16.6	1.6	4.5	8.7	0.7	14.8	9.3	62.5
Red clover silage	5	44	45	35	48	45	57	12.3	1.5	4.0	5.2	0.5	10.3	6.9	66.7
Apple pomace silage	Assume apple pomace							14.6	...	2.8	10.2	0.6	14.4	....	....
Potatoes	23	85	..	61	..	90	..	17.9	1.3	....	15.6	....	17.6	12.0	77.0
Beets		Assume sugar beets						10.9	1.4	0.9	8.0	0.5	10.0	7.1	71.4
Sugar beets	28	89	..	62	..	95	..	12.0	1.1	....	9.3	....	9.3	8.5	90.9
Carrots		Assume sugar beets						10.6	1.0	1.3	7.4	0.4	9.6	9.6	100.0
Mangels	18	88	..	77	..	96	..	81.0	1.1	....	5.3	....	8.0	4.8	90.9
Rutabagas	2	87	..	80	74	95	84	9.9	1.0	1.0	7.1	0.2	8.6	8.6	100.0
Turnips (flat)	2	93	..	90	100	97	98	8.8	1.0	1.2	6.0	0.2	7.7	7.7	100.0
Miscellaneous															
Apples	No basis for assumption														
Apple pomace	6	72	..	..	65	85	46	16.8	....	2.5	13.8	0.6	17.7	....	....
Pumpkins	No basis for assumption														
Cabbage	No basis for assumption														
Rape	4	85	..	89	87	92	48	8.9	2.0	2.8	7.3	0.2	10.1	5.1	50.0

TABLE III. AMERICAN DIGESTION COEFFICIENTS; DIGESTIBLE INGREDIENTS OF AMERICAN FEEDING STUFFS—*Concluded*

FODDERS	Number of trials	Digestion coefficients						Percentage of digestible ingredients							
		Dry matter	Organic matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Dry matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Total digestible carbohydrates	Nutritive ratio (2nd term)	Protein equating factor
Skimmilk (sep.)...	8	97	100	94	..	100	100	9.1	2.9	...	5.8	0.3	6.0	2.1	34.5
Buttermilk		Assume skimmilk						9.6	3.8	...	4.0	1.1	6.5	1.7	26.3
Whey		Assume skimmilk						6.0	0.6	...	5.1	0.1	5.3	8.8	166.7
Dried blood	2	63	..	62	..	100	100	57.6	52.3	...	...	2.5	5.6	0.1	1.9
Meat scrap.......	5	93	..	93	..	..	98	83.0	66.2	...	...	13.4	29.8	0.5	1.5
Meat and bone meal		No basis for assumption													
Beet molasses		No basis for assumption													
Porto Rico molasses		No basis for assumption													
CONCENTRATES															
Grains and byproducts															
Corn meal	21	88	90	66	..	92	91	74.8	6.1	...	68.2	3.5	71.1	11.7	16.4
Corn and cob meal.	3	79	..	52	45	88	84	67.1	4.4	3.0	57.0	2.9	66.5	15.1	22.7
Corn cobs	2	59	..	17	65	60	50	54.3	0.5	20.3	38.7	0.3	54.7	109.4	200.0
Corn (dent)	12	91	..	76	58	93	86	81.3	7.8	1.3	65.5	4.3	76.5	9.8	12.8
Corn (flint)								80.7	8.0	1.0	65.2	4.3	74.9	9.4	12.5
Corn (sweet).....								83.0	8.8	1.6	62.1	7.0	79.4	9.0	11.4
Corn bran	4	70	..	54	59	77	77	63.6	4.9	7.5	47.9	4.5	65.5	13.4	20.4
Gluten feed	13	86	93	85	76	89	83	79.3	20.4	4.0	45.6	8.8	69.4	3.4	4.9
Hominy chop	8	82	..	65	67	89	92	75.1	7.3	3.3	57.8	7.3	77.5	10.6	13.7
Distillers' dried grs.	7	79	..	73	95	81	95	72.7	23.1	11.7	27.7	11.5	65.3	2.8	4.3
Rye.............	2	58	..	59	..	67	84								
Wheat		82	..	80	60	83	70	73.4	1.1	59.7	...	1.5	9.5	6.8	10.5
Wheat bran	10	66	..	77	39	71	63	58.2	3.5	38.3	...	2.5	11.9	4.0	8.4
Wheat bran (spring)	7	67	71	76	44	74	63	59.3	3.5	40.3	...	2.8	12.2	4.1	8.2
Wheat bran (win.).	3	62	..	77	27	65	64	54.4	2.2	34.9	...	2.6	12.3	4.3	8.1
Wheat middlings															
(flour)	4	82	83	88	36	88	86	73.8	1.2	52.4	...	4.1	14.3	4.4	7.0
(standard) ...	6	..	73	77	30	78	88	65.7	2.1	43.5	...	4.4	13.8	4.0	7.3
Wheat screenings.		No basis for assumption													
Wheat (mixed feed)	4	73	76	78	62	77	87	65.1	4.6	42.2	...	4.1	13.1	4.3	7.7
Red dog flour....	2	67	70	79	..	76	..	60.5	...	42.7	...	...	15.7	2.7	6.4
Rye meal	2	87	..	84	..	92	64	76.9	...	66.7	...	1.1	8.9	7.8	11.2
Rye bran	4	62	..	64	21	78	72	54.8	0.7	49.7	...	2.0	9.4	5.8	10.6
Barley	4	86	..	70	50	92	89	76.6	1.4	64.2	....	1.6	8.7	8.0	11.5
Barley screenings.		No basis for assumption													
Brewers' dried grs..	5	62	..	81	49	57	89	55.8	5.9	26.0	...	4.9	19.1	2.3	5.2
Malt sprouts	3	82	..	76	99	85	87	73.7	10.6	41.2	...	1.5	17.6	3.1	5.7
Oats	39	70	..	78	20	76	83	62.3	1.9	45.4	...	4.2	9.2	6.2	10.9
Oat hulls [1]	6	40	..	65	32	42	90	37.1	9.5	21.9	...	0.9	2.1	15.9	47.6
Provender		79	..	72	10	84	87	68.7	0.6	53.9	...	3.8	7.6	8.3	13.2
Buckwheat		No basis for assumption													
Buckwheat hulls....		No basis for assumption													
Buckwheat bran....		No basis for assumption													
Buckwheat midl'gs	3	75	..	85	17	83	89	66.4	0.7	37.6	...	6.2	23.4	2.2	4.3
Cottonseed meal...	12	79	88	84	35	78	94	72.5	2.0	18.4	...	12.3	36.0	1.3	2.8
Cottonseed hulls...	13	41	..	6	47	34	79	36.4	21.8	11.3	...	1.7	0.3	123.0	333.3
Linseed meal															
(old process).	3	79	..	89	57	78	89	71.2	4.6	26.6	...	6.7	30.8	1.5	3.2
(new process)	12	82	79	84	74	80	89	73.2	6.1	27.8	...	2.3	32.0	1.2	3.1
Pea meal	2	87	88	83	26	94	55	77.8	3.7	47.9	...	6.2	16.8	3.9	6.0

[1] Oat feeds with excessive hulls.

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS.

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Green grasses, etc.	Pasture grass			Timothy			Red top			Ky. blue grass		
2½	0.5	0.06	0.3	1.0	0.04	0.5	0.9	0.05	0.6	0.9	0.07	0.5
5	1.0	0.12	0.6	1.9	0.08	1.0	1.8	0.10	1.2	1.8	0.14	1.0
10	2.0	0.25	1.1	3.8	0.16	2.0	3.5	0.20	2.3	3.5	0.29	2.1
15	3.0	0.37	1.7	5.7	0.24	3.0	5.3	0.30	3.5	5.3	0.44	3.2
20	4.0	0.50	2.2	7.7	0.32	4.1	7.0	0.40	4.6	7.0	0.58	4.3
25	5.0	0.63	2.8	9.5	0.40	5.1	8.7	0.50	5.8	8.8	0.72	5.3
30	6.0	0.75	3.4	11.4	0.48	6.1	10.4	0.60	6.9	10.5	0.87	6.4
35	7.0	0.88	4.0	13.4	0.56	7.2	12.2	0.70	8.0	12.3	1.02	7.5
40	8.0	1.00	4.5	15.4	0.64	8.2	13.9	0.80	9.2	14.0	1.16	8.5
Green grasses, etc.	Orchard grass			Rowen			Hungarian			Japanese millet		
2½	0.7	0.04	0.3	0.8	0.08	0.4	0.8	0.05	0.4	0.6	0.03	0.4
5	1.4	0.08	0.6	1.5	0.16	0.8	1.5	0.10	0.8	1.3	0.06	0.7
10	2.7	0.15	1.3	3.0	0.32	1.6	2.9	0.21	1.7	2.5	0.11	1.4
15	4.0	0.23	2.0	4.5	0.48	2.4	4.4	0.30	2.5	3.8	0.16	2.1
20	5.4	0.30	2.6	6.0	0.64	3.2	5.8	0.40	3.4	5.0	0.22	2.9
25	6.8	0.38	3.2	7.5	0.80	4.0	7.3	0.50	4.2	6.3	0.28	3.6
30	8.1	0.45	3.9	9.0	0.96	4.9	8.7	0.60	5.0	7.5	0.33	4.3
35	9.5	0.52	4.6	10.5	1.12	5.7	10.7	0.70	5.9	8.8	0.38	5.0
40	10.8	0.60	5.2	12.0	1.28	6.5	11.6	0.80	6.7	10.0	0.44	5.7
Green cereals, etc.	Barn yard millet			Barley fodder			Oat fodder			Rye fodder		
2½	0.6	0.04	0.4	0.6	0.06	0.4	1.0	0.06	0.5	0.6	0.05	0.4
5	1.3	0.08	0.8	1.3	0.12	0.7	1.9	0.12	1.0	1.2	0.10	0.8
10	2.5	0.16	1.5	2.5	0.24	1.4	3.8	0.25	2.0	2.3	0.21	1.5
15	3.8	0.24	2.3	3.8	0.36	2.0	5.7	0.38	3.0	3.5	0.32	2.2
20	5.0	0.32	3.0	5.0	0.48	2.7	7.6	0.50	4.0	4.7	0.42	3.0
25	6.3	0.40	3.8	6.3	0.60	3.4	9.5	0.62	5.0	5.9	0.52	3.8
30	7.5	0.48	4.5	7.5	0.72	4.1	11.4	0.75	6.1	7.1	0.63	4.5
35	8.8	0.56	5.3	8.8	0.84	4.8	13.2	0.88	7.1	8.3	0.74	5.2
40	10.0	0.64	6.0	9.9	0.96	5.4	15.1	1.00	8.1	9.4	0.84	6.0
Green cereals, etc.	Oats and peas			Barley and peas			Fodder corn			Dent corn (mature)		
2½	0.5	0.07	0.3	0.5	0.07	0.3	0.5	0.03	0.3	0.7	0.03	0.3
5	1.1	0.13	0.6	1.0	0.14	0.5	1.0	0.06	0.6	1.4	0.06	0.6
10	2.1	0.26	1.1	2.1	0.27	1.1	2.1	0.11	1.3	2.7	0.11	1.3
15	3.2	0.39	1.7	3.1	0.40	1.6	3.1	0.16	1.9	4.0	0.16	2.0
20	4.3	0.52	2.2	4.1	0.54	2.2	4.1	0.22	2.6	5.2	0.22	2.6
25	5.4	0.65	2.8	5.1	0.68	2.7	5.1	0.28	3.2	6.5	0.28	3.2
30	6.4	0.78	3.3	6.2	0.81	3.2	6.2	0.33	3.9	7.8	0.33	3.9
35	7.5	0.91	3.9	7.2	0.94	3.8	7.2	0.38	4.5	9.1	0.38	4.5
40	8.5	1.04	4.4	8.2	1.08	4.3	8.3	0.44	5.2	10.4	0.44	5.2
Green corn	Dent corn (immature)			Flint corn			Flint corn (mature)			Sweet corn		
2½	0.6	0.03	0.4	0.5	0.02	0.3	0.6	0.03	0.4	0.5	0.03	0.3
5	1.1	0.06	0.8	1.0	0.05	0.6	1.2	0.07	0.7	1.1	0.06	0.7
10	2.1	0.11	1.7	2.0	0.10	1.3	2.3	0.14	1.5	2.1	0.12	1.3
15	3.3	0.16	2.5	3.0	0.15	2.0	3.5	0.21	2.2	3.1	0.18	2.0
20	4.4	0.22	3.3	4.0	0.20	2.6	4.6	0.28	2.9	4.2	0.24	2.7
25	5.5	0.27	4.2	5.0	0.25	3.2	5.8	0.35	3.7	5.2	0.30	3.4
30	6.6	0.33	5.0	6.0	0.30	3.9	6.9	0.42	4.4	6.3	0.36	4.0
35	7.7	0.38	5.8	7.1	0.35	4.5	8.1	0.49	5.1	7.3	0.42	4.7
40	8.7	0.44	6.7	8.1	0.40	5.2	9.2	0.56	5.9	8.4	0.48	5.4

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS—*Continued*

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Green legumes		**Red clover**			**Alsike clover**			**Clover rowen**			**Canada peas**	
2½	0.7	0.07	0.4	0.6	0.07	0.3	0.6	0.07	0.3	0.4	0.06	0.2
5	1.5	0.15	0.8	1.3	0.13	0.6	1.3	0.15	0.6	0.8	0.13	0.3
10	2.9	0.29	1.6	2.5	0.26	1.3	2.5	0.29	1.2	1.5	0.26	0.7
15	4.4	0.44	2.5	3.8	0.39	1.9	3.8	0.44	1.8	2.3	0.39	1.0
20	5.9	0.58	3.3	5.1	0.52	2.6	5.0	0.58	2.4	3.0	0.52	1.4
25	7.4	0.72	4.1	6.4	0.65	3.2	6.3	0.72	8.0	3.8	0.65	1.7
30	8.8	0.87	4.9	7.6	0.78	3.8	7.5	0.87	3.6	4.5	0.78	2.0
35	10.3	1.02	5.7	8.9	0.91	4.5	8.8	1.02	4.2	5.3	0.91	2.4
40	11.7	1.16	6.6	10.1	1.04	5.1	10.0	1.16	4.8	6.0	1.04	2.7
Green Legumes		**Alfalfa**			**Soy bean**							
2½	0.7	0.09	0.3	0.6	0.08	0.3						
5	1.4	0.18	0.7	1.3	0.16	0.6						
10	2.8	0.36	1.3	2.5	0.31	1.2						
15	4.3	0.54	1.9	3.8	0.46	1.8						
20	5.7	0.72	2.6	5.0	0.62	2.4						
25	7.1	0.90	3.3	6.3	0.78	3.0						
30	8.5	1.08	3.9	7.5	0.93	3.6						
35	9.9	1.26	4.6	8.8	1.09	4.2						
40	11.3	1.44	5.2	10.0	1.24	4.8						
Hay		**Mixed hay**			**Timothy**			**Timothy (bloom)**			**Timothy (after bloom)**	
2½	2.2	0.10	1.1	2.2	0.07	1.1	2.2	0.08	1.2	2.2	0.06	1.1
5	4.3	0.21	2.2	4.4	0.14	2.3	4.3	0.17	2.3	4.3	0.12	2.1
7½	6.4	0.31	3.4	6.6	0.21	3.4	6.4	0.26	3.5	6.5	0.19	3.2
10	8.5	0.42	4.5	8.7	0.28	4.5	8.5	0.34	4.7	8.6	0.25	4.3
12½	10.7	0.53	5.6	10.9	0.35	5.7	10.7	0.42	5.8	10.8	0.31	5.3
15	12.8	0.63	6.8	13.1	0.42	6.8	12.8	0.51	7.0	13.0	0.38	6.4
17½	14.9	0.74	7.9	15.3	0.49	7.9	14.9	0.60	8.1	15.1	0.44	7.5
20	17.0	0.84	9.0	17.4	0.56	9.1	17.0	0.68	9.3	17.2	0.50	8.5
25	21.3	1.05	11.2	21.8	0.70	11.3	21.3	0.85	11.6	21.6	0.62	10.6
Hay		**Timothy (ripe)**			**Red top**			**Kentucky blue grass**			**Witch grass**	
2½	2.2	0.06	1.1	2.3	0.12	1.2	1.9	0.09	0.9			
5	4.3	0.11	2.1	4.5	0.24	2.4	3.7	0.18	1.8			
7½	6.5	0.17	3.2	6.8	0.36	3.7	5.6	0.26	2.7			
10	8.6	0.22	4.3	9.1	0.48	4.9	7.4	0.35	3.6			
12½	10.8	0.28	5.3	11.4	0.60	6.1	9.3	0.44	4.5			
15	13.0	0.33	6.4	13.7	0.72	7.4	11.1	0.52	5.5			
17½	15.1	0.38	7.5	16.0	0.84	8.6	13.0	0.61	6.4			
20	17.2	0.44	8.5	18.2	0.96	9.8	14.8	0.70	7.3			
25	21.6	0.55	10.6	22.8	1.20	12.2	18.5	0.88	9.1			
Hay		**Orchard grass**			**Rowen (mixed)**			**Rowen (fine)**			**Hungarian**	
2½	2.8	0.12	1.1	2.1	0.20	1.1	2.2	0.24	1.1	2.1	0.12	1.2
5	4.5	0.24	2.3	4.2	0.41	2.2	4.4	0.49	2.2	4.2	0.24	2.5
7½	6.8	0.37	8.4	6.2	0.61	3.3	6.6	0.74	3.4	6.3	0.37	3.7
10	9.0	0.49	4.6	8.3	0.81	4.4	8.7	0.98	4.5	8.4	0.49	5.0
12½	11.3	0.61	5.7	10.4	1.01	5.5	10.9	1.23	5.6	10.5	0.61	6.2
15	13.5	0.74	6.8	12.5	1.22	6.6	13.1	1.47	6.7	12.6	0.74	7.4
17½	15.8	0.86	8.0	14.6	1.42	7.7	15.3	1.72	7.8	14.7	0.86	8.7
20	18.0	0.98	9.1	16.6	1.62	8.8	17.4	1.96	9.0	16.8	0.98	9.9
25	22.5	1.23	11.4	20.8	2.03	11.0	21.8	2.45	11.2	21.0	1.23	12.4

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS—*Continued*

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Hay	**Barley hay**			**Oat hay (in milk)**			**Oat hay**			**Oat and pea hay**		
2½	2.2	0.14	1.1	2.2	0.12	1.0	2.3	0.10	1.1	2.2	0.27	1.1
5	4.3	0.28	2.3	4.3	0.24	2.0	4.5	0.20	2.2	4.4	0.54	2.1
7½	6.4	0.43	3.4	6.4	0.36	2.9	6.8	0.30	3.3	6.6	0.81	3.2
10	8.5	0.57	4.6	8.5	0.48	3.9	9.1	0.40	4.4	8.8	1.08	4.4
12½	10.7	0.71	5.7	10.7	0.60	4.9	11.4	0.50	5.5	11.0	1.35	5.3
15	12.8	0.86	6.8	12.8	0.72	5.9	13.7	0.60	6.6	13.2	1.62	6.4
17½	14.9	1.00	8.0	14.9	0.84	6.9	16.0	0.70	7.7	15.4	1.90	7.4
20	17.0	1.14	9.1	17.0	0.96	7.8	18.2	0.80	8.8	17.6	2.16	8.5
25	21.3	1.43	11.4	21.3	1.20	9.8	22.8	1.00	11.0	22.0	2.70	10.6
Straw	**Barley straw**			**Oat straw**			**Wheat straw**			**Rye straw**		
2½	2.2	0.02	1.1	2.3	0.03	1.0	2.3	0.01	0.9	2.3	0.02	1.0
5	4.3	0.04	2.2	4.5	0.06	2.0	4.5	0.02	1.9	4.7	0.03	2.1
7½	6.5	0.05	3.2	6.8	0.09	3.0	6.7	0.03	2.8	7.0	0.04	3.1
10	8.6	0.07	4.3	9.1	0.12	4.1	9.0	0.04	3.7	9.3	0.06	4.1
12½	10.8	0.09	5.4	11.4	0.15	5.1	11.3	0.05	4.6	11.7	0.08	5.2
15	13.0	0.11	6.4	13.7	0.18	6.1	13.5	0.06	5.6	14.0	0.09	6.2
17½	15.1	0.12	7.5	16.0	0.21	7.1	15.8	0.07	6.5	16.3	0.10	7.3
20	17.2	0.14	8.6	18.2	0.24	8.1	18.0	0.08	7.5	18.6	0.12	8.3
25	21.6	0.18	10.8	22.8	0.30	10.1	22.5	0.10	9.3	23.4	0.15	10.4
Hays, etc.	**Corn fodder**			**Corn stover**			**Mixed grasses and clover**			**Red clover**		
2½	1.5	0.06	0.9	1.5	0.04	0.8	2.2	0.10	1.1	2.2	0.18	1.0
5	2.9	0.13	1.8	3.0	0.07	1.7	4.4	0.19	2.1	4.3	0.35	2.1
7½	4.4	0.19	2.7	4.5	0.11	2.5	6.7	0.29	3.2	6.4	0.53	3.1
10	5.8	0.25	3.5	6.0	0.14	3.3	8.7	0.38	4.3	8.5	0.71	4.2
12½	7.3	0.31	4.5	7.5	0.18	4.2	10.9	0.48	5.4	10.7	0.89	5.2
15	8.7	0.38	5.4	9.0	0.21	5.0	13.1	0.57	6.4	12.8	1.06	6.3
17½	10.2	0.44	6.2	10.5	0.25	5.8	15.3	0.66	7.5	14.9	1.24	7.3
20	11.6	0.50	7.1	12.0	0.28	6.6	17.4	0.76	8.6	17.0	1.42	8.4
25	14.5	0.63	8.9	15.0	0.35	8.3	21.8	0.95	10.7	21.3	1.78	10.5
Legume hays	**Red clover (in bloom)**			**Mammoth clover**			**Alsike clover**			**Clover rowen**		
2½	2.0	0.19	1.0	2.0	0.16	1.0	2.3	0.21	1.1	2.3	0.21	1.0
5	4.0	0.38	2.0	4.0	0.31	2.0	4.5	0.42	2.1	4.6	0.43	2.1
7½	6.0	0.58	3.0	6.0	0.46	3.0	6.8	0.63	3.2	6.9	0.64	3.1
10	7.9	0.77	4.0	7.9	0.62	4.0	9.0	0.84	4.2	9.2	0.85	4.2
12½	9.9	0.96	5.0	9.9	0.78	5.0	11.3	1.05	5.3	11.5	1.06	5.2
15	11.9	1.16	6.1	11.9	0.93	6.0	13.5	1.25	6.3	13.8	1.28	6.3
17½	13.8	1.35	7.1	13.8	1.09	7.0	15.8	1.47	7.4	16.1	1.49	7.3
20	15.8	1.54	8.1	15.8	1.24	8.0	18.0	1.68	8.4	18.4	1.70	8.4
25	19.8	1.93	10.1	19.8	1.55	10.0	22.5	2.10	10.5	23.0	2.13	10.5
Legume hays	**Alfalfa**			**Soy bean**								
2½	2.3	0.26	1.1	2.2	0.27	1.1						
5	4.6	0.51	2.2	4.4	0.54	2.2						
7½	6.9	0.77	3.3	6.7	0.82	3.3						
10	9.2	1.03	4.5	8.9	1.09	4.4						
12½	11.5	1.29	5.5	11.1	1.36	5.5						
15	13.8	1.55	6.7	13.3	1.64	6.5						
17½	16.1	1.80	7.8	15.6	1.91	7.6						
20	18.4	2.06	8.9	17.8	2.18	8.7						
25	23.0	2.58	11.1	22.3	2.72	10.9						

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS—*Continued*

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Silage	**Corn silage (mature)**			**Corn silage (immature)**			**Stover silage**			**Corn and soy bean silage**		
2½	0.7	0.03	0.4	0.5	0.02	0.3	0.5	0.02	0.2	0.6	0.04	0.4
5	1.3	0.06	0.8	1.1	0.04	0.7	1.0	0.03	0.5	1.2	0.08	0.7
10	2.6	0.11	1.7	2.1	0.09	1.3	1.9	0.06	1.0	2.4	0.16	1.5
15	3.9	0.16	2.5	3.1	0.14	1.9	2.9	0.09	1.5	3.6	0.24	2.2
20	5.2	0.22	3.3	4.2	0.18	2.6	3.8	0.12	2.0	4.8	0.32	3.0
25	6.5	0.28	4.2	5.3	0.22	3.2	4.8	0.15	2.5	6.0	0.40	3.7
30	7.8	0.33	5.0	6.3	0.27	3.9	5.7	0.18	3.0	7.2	0.48	4.4
35	9.2	0.38	5.8	7.4	0.31	4.5	6.7	0.21	3.5	8.4	0.56	5.2
40	10.5	0.44	6.6	8.4	0.36	5.1	7.7	0.24	4.0	9.6	0.64	5.9
Silage	**Red clover silage**			**Apple pomace silage**								
2½	0.7	0.04	0.3	0.5	....	0.4						
5	1.4	0.08	0.5	1.0	....	0.7						
10	2.8	0.15	1.0	2.0	....	1.5						
15	4.2	0.22	1.5	3.0	....	2.2						
20	5.6	0.30	2.1	4.0	....	2.9						
25	7.0	0.38	2.6	5.0	....	3.7						
30	8.4	0.45	3.1	6.0	....	4.4						
35	9.8	0.52	3.6	7.1	....	5.1						
40	11.2	0.60	4.1	8.1	....	5.9						
Roots, etc.	**Potatoes.**			**Beets**			**Sugar beets**			**Carrots**		
2½	0.5	0.03	0.4	0.3	0.04	0.2	0.3	0.03	0.2	0.3	0.02	0.2
5	1.1	0.07	0.8	0.6	0.07	0.5	0.7	0.06	0.5	0.6	0.05	0.5
10	2.1	0.13	1.6	1.2	0.14	1.0	1.4	0.11	0.9	1.2	0.10	1.0
15	3.1	0.20	2.3	1.8	0.21	1.5	2.1	0.16	1.4	1.8	0.15	1.4
20	4.2	0.26	3.1	2.4	0.28	2.0	2.8	0.22	1.9	2.4	0.20	1.9
25	5.2	0.32	3.9	2.9	0.35	2.5	3.4	0.28	2.3	2.9	0.25	2.4
30	6.3	0.39	4.7	3.5	0.42	3.0	4.1	0 33	2.8	3.5	0.30	2.9
35	7.3	0.45	5.5	4.1	0.49	3.5	4.8	0.39	3.3	4.1	0.35	3.4
40	8.4	0.52	6.2	4.6	0.56	4.0	5.4	0.44	3.7	4.6	0.40	3.8
Roots	**Mangels**			**Rutabagas**			**Turnips (flat)**					
2½	0.2	0.03	0.1	0.3	0.03	0.2	0.3	0.02	0.2			
5	0.5	0.05	0.3	0.6	0.05	0.4	0.5	0.05	0.4			
10	0.9	0.11	0.5	1.1	0.10	0.9	1.0	0.10	0.8			
15	1.3	0.16	0.8	1.7	0.15	1.3	1.5	0.15	1.2			
20	1.8	0.22	1.1	2.3	0.20	1.7	2.0	0.20	1.5			
25	2.3	0.28	1.3	2.9	0.25	2.2	2.5	0.25	1.9			
30	2.7	0.33	1.6	3.5	0.30	2.6	2.9	0.30	2.3			
35	3.1	0.38	1.9	4.1	0.35	3.0	3.4	0.35	2.7			
40	3.6	0.44	2.1	4.6	0.40	3.4	3.8	0.40	3.1			
Misc.	**Apple pomace**			**Rape**			**Skimmilk**			**Buttermilk**		
2½	0.6	....	0.4	0.4	0.05	0.3	0.3	0.07	0.2	0.3	0.10	0.2
5	1.2	....	0.9	0.7	0.10	0.5	0.5	0.15	0.3	0.5	0.19	0.3
10	2.3	....	1.8	1.5	0.20	1.0	0.9	0.29	0.6	1.0	0.38	0.7
15	3.5	....	2.7	2.3	0.30	1.5	1.4	0.43	0.9	1.5	0.57	1.0
20	4.7	....	3.5	3.1	0.40	2.0	1.9	0.58	1.2	2.0	0.76	1.3
25	5.8	....	4.4	3.9	0.50	2.5	2.4	0.72	1.5	2.5	0.95	1.6
30	7.0	....	5.3	4.6	0.60	3.0	2.9	0.87	1.8	3.0	1.14	2.0
35	8.2	....	6.2	5.4	0.70	3.5	3.4	1.02	2.1	3.5	1.33	2.3
40	9.3	....	7.1	6.2	0.80	4.0	3.8	1.16	2.4	4.0	1.52	2.6

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS—*Continued*

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Misc.		**Whey**										
2½	0.2	0.02	0.1									
5	0.3	0.03	0.3									
10	0.6	0.06	0.5									
15	0.9	0.09	0.8									
20	1.2	0.12	1.1									
25	1.5	0.15	1.3									
30	1.8	0.18	1.6									
35	2.2	0.21	1.9									
40	2.5	0.24	2.1									
Corn products		**Corn meal**			**Corn and cob meal**			**Corn (dent)**			**Corn (flint)**	
¼	0.2	0.02	0.2	0.2	0.01	0.2	0.2	0.02	0.2	0.2	0.02	0.2
½	0.4	0.03	0.4	0.4	0.02	0.3	0.4	0.04	0.4	0.4	0.04	0.4
1	0.9	0.06	0.7	0.9	0.04	0.7	0.9	0.08	0.8	0.9	0.08	0.7
2	1.8	0.12	1.4	1.8	0.09	1.3	1.8	0.16	1.5	1.8	0.16	1.5
3	2.6	0.18	2.1	2.6	0.13	2.0	2.7	0.23	2.3	2.7	0.24	2.2
4	3.5	0.24	2.8	3.5	0.18	2.7	3.6	0.31	3.1	3.6	0.32	3.0
5	4.3	0.30	3.6	4.3	0.22	3.3	4.5	0.39	3.8	4.5	0.40	3.7
7½	6.4	0.46	5.3	6.4	0.33	5.0	6.7	0.58	5.7	6.7	0.60	5.6
10	8.5	0.61	7.1	8.5	0.44	6.7	8.9	0.78	7.7	8.9	0.80	7.5
Corn products		**Corn (sweet)**			**Corn cobs**			**Corn bran**			**Gluten feed**	
¼	0.2	0.02	0.2	0.2	....	0.1	0.2	0.01	0.2	0.2	0.05	0.2
½	0.4	0.04	0.4	0.4	....	0.3	0.4	0.02	0.3	0.4	0.10	0.3
1	0.9	0.09	0.8	0.9	0.01	0.5	0.9	0.05	0.7	0.9	0.20	0.7
2	1.8	0.18	1.6	1.8	0.01	1.1	1.8	0.10	1.3	1.8	0.41	1.4
3	2.7	0.26	2.4	2.7	0.02	1.6	2.7	0.15	2.0	2.8	0.61	2.1
4	3.6	0.35	3.2	3.6	0.02	2.2	3.6	0.20	2.6	3.7	0.82	2.8
5	4.6	0.44	4.0	4.5	0.02	2.7	4.6	0.24	3.3	4.7	1.02	3.5
7½	6.8	0.66	6.0	6.7	0.04	4.1	6.8	0.37	4.9	7.0	1.53	5.2
10	9.1	0.88	7.9	8.9	0.05	5.4	9.1	0.49	6.6	9.2	2.04	6.9
Corn products		**Hominy chops**			**Distillers' dried grs.**			**Distillers' rye grs.**				
¼	0.2	0.02	0.2	0.2	0.06	0.2						
½	0.4	0.04	0.4	0.4	0.12	0.3						
1	0.9	0.07	0.8	0.9	0.23	0.7						
2	1.8	0.15	1.6	1.8	0.46	1.3						
3	2.8	0.22	2.3	2.8	0.69	2.0						
4	3.7	0.29	3.1	3.7	0.92	2.6						
5	4.7	0.37	3.9	4.7	1.15	3.3						
7½	7.0	0.55	5.8	7.0	1.73	4.9						
10	9.2	0.73	7.8	9.2	2.31	6.5						
Wheat products		**Wheat**			**Wheat bran**			**Wheat bran (spring)**			**Wheat bran (winter)**	
¼	0.2	0.03	0.2	0.2	0.03	0.1	0.2	0.03	0.1	0.2	0.03	0.1
½	0.4	0.05	0.3	0.4	0.06	0.2	0.4	0.06	0.2	0.4	0.06	0.3
1	0.9	0.10	0.6	0.9	0.12	0.5	0.9	0.12	0.5	0.9	0.12	0.5
2	1.8	0.20	1.3	1.8	0.24	1.0	1.8	0.24	1.0	1.8	0.25	1.1
3	2.7	0.29	1.9	2.6	0.36	1.4	2.7	0.37	1.5	2.6	0.37	1.6
4	3.6	0.39	2.6	3.5	0.48	1.9	3.6	0.49	2.0	3.5	0.50	2.1
5	4.5	0.48	3.2	4.4	0.60	2.4	4.5	0.61	2.5	4.4	0.62	2.7
7½	6.7	0.72	4.8	6.6	0.89	3.6	6.7	0.92	3.8	6.6	0.93	4.0
10	8.9	0.95	6.4	8.8	1.19	4.7	8.8	1.22	5.0	8.8	1.23	5.3

TABLE IV. POUNDS OF TOTAL DRY MATTER AND OF DIGESTIBLE INGREDIENTS—*Concluded*

Pounds of fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Wheat products	**Wheat middlings (flour)**			**Wheat middlings (standard)**			**Wheat mixed feed**			**Red dog feeding flour**		
¼	0.2	0.04	0.2	0.2	0.04	0.1	0.2	0.03	0.1	0.2	0.04	0.1
½	0.4	0.07	0.3	0.4	0.07	0.3	0.4	0.06	0.3	0.4	0.08	0.2
1	0.9	0.14	0.6	0.9	0.14	0.6	0.9	0.13	0.6	0.9	0.16	0.4
2	1.8	0.28	1.2	1.8	0.28	1.1	1.8	0.26	1.1	1.8	0.31	0.9
3	2.7	0.43	1.9	2.7	0.41	1.7	2.7	0.39	1.7	2.7	0.47	1.3
4	3.6	0.57	2.5	3.6	0.55	2.2	3.6	0.52	2.2	3.6	0.63	1.7
5	4.5	0.72	3.1	4.5	0.69	2.8	4.5	0.65	2.8	4.5	0.78	2.1
7½	6.8	1.08	4.7	6.8	1.03	4.2	6.7	0.98	4.2	6.8	1.18	3.2
10	9.0	1.43	6.2	9.0	1.38	5.6	8.9	1.31	5.6	9.0	1.57	4.3
ye, etc., products	**Rye**			**Rye bran**			**Barley**			**Brewers dried grains**		
¼	0.2	0.02	0.2	0.2	0.02	0.1	0.2	0.02	0.2	0.2	0.05	0.1
½	0.4	0.04	0.3	0.4	0.05	0.3	0.4	0.04	0.3	0.4	0.10	0.2
1	0.9	0.09	0.7	0.9	0.09	0.5	0.9	0.09	0.7	0.9	0.19	0.4
2	1.8	0.18	1.4	1.8	0.19	1.1	1.8	0.17	1.3	1.8	0.38	0.9
3	2.6	0.27	2.1	2.6	0.28	1.6	2.7	0.26	2.0	2.6	0.57	1.3
4	3.5	0.35	2.8	3.5	0.38	2.2	3.6	0.35	2.8	3.5	0.76	1.7
5	4.4	0.45	3.5	4.4	0.47	3.0	4.5	0.43	3.5	4.4	0.96	2.1
7½	6.6	0.67	5.2	6.6	0.70	4.1	6.7	0.65	5.2	6.6	1.43	3.2
10	8.8	0.89	6.9	8.8	0.94	5.5	8.9	0.87	6.9	8.8	1.91	4.3
Oat roducts	**Malt sprouts**			**Oats**			**Oat hulls**			**Provender (½corn, ½oats)**		
¼	0.2	0.04	0.1	0.2	0.02	0.1	0.2	0.01	0.1	0.2	0.02	0.2
½	0.4	0.09	0.3	0.4	0.05	0.3	0.4	0.01	0.2	0.4	0.04	0.3
1	0.9	0.18	0.5	0.9	0.09	0.6	0.9	0.02	0.3	0.9	0.08	0.6
2	1.8	0.35	1.1	1.8	0.18	1.1	1.9	0.04	0.7	1.7	0.15	1.2
3	2.7	0.53	1.7	2.7	0.28	1.7	2.8	0.06	1.0	2.6	0.23	1.9
4	3.6	0.70	2.2	3.6	0.37	2.3	3.8	0.08	1.3	3.5	0.30	2.5
5	4.5	0.88	2.8	4.5	0.46	2.8	4.7	0.10	1.7	4.4	0.38	3.2
7½	6.8	1.32	4.1	6.7	0.69	4.3	7.0	0.16	2.5	6.6	0.57	4.7
10	9.0	1.76	5.5	8.9	0.92	5.7	9.3	0.21	3.3	8.7	0.76	6.3
isc.	**Buckwheat middlings**			**Cottonseed meal**			**Cottonseed hulls**			**Linseed meal (O. P.)**		
¼	0.2	0.06	0.1	0.2	0.09	0.1	0.2	....	0.1	0.2	0.07	0.1
½	0.4	0.12	0.3	0.4	0.18	0.2	0.4	....	0.2	0.4	0.15	0.2
1	0.9	0.23	0.5	0.9	0.36	0.5	0.9	....	0.4	0.9	0.31	0.5
2	1.8	0.47	1.0	1.9	0.72	1.0	1.8	0.01	0.7	1.8	0.62	0.9
3	2.6	0.70	1.6	2.8	1.08	1.4	2.7	0.01	1.1	2.7	0.92	1.4
4	3.5	0.94	2.1	3.8	1.44	1.9	3.6	0.01	1.5	3.6	1.24	1.8
5	4.4	1.17	2.6	4.6	1.80	2.4	4.5	0.02	1.8	4.5	1.54	2.3
7½	6.6	1.75	3.9	6.9	2.70	3.6	6.7	0.02	2.8	6.7	2.31	3.5
10	8.8	2.34	5.2	9.2	3.60	4.8	8.9	0.03	3.7	9.0	3.08	4.6
isc.	**Linseed meal (N. P.)**			**Pea meal**			**Dried blood**			**Meat scrap**		
¼	0.2	0.08	0.1	0.2	0.04	0.2	0.2	0.13	...	0.2	0.17	0.1
½	0.4	0.16	0.2	0.4	0.09	0.3	0.4	0.26	...	0.4	0.33	0.2
1	0.9	0.32	0.4	0.9	0.17	0.7	0.9	0.52	0.1	0.9	0.66	0.3
2	1.8	0.64	0.8	1.8	0.34	1.3	1.8	1.06	0.1	1.8	1.31	0.6
3	2.7	0.96	1.2	2.7	0.50	2.0	2.7	1.58	0.1	2.7	1.96	0.9
4	3.6	1.28	1.6	3.6	0.67	2.6	3.6	2.11	0.2	3.6	2.62	1.2
5	4.5	1.60	2.0	4.5	0.84	3.3	4.6	2.62	0.3	4.5	3.31	1.5
7½	6.7	2.40	2.9	6.7	1.26	4.9	6.8	3.93	0.4	6.7	4.97	2.2
10	8.9	3.20	3.9	8.9	1.68	6.6	9.1	5.23	0.6	8.9	6.62	3.0

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN NO. 153

MAY, 1910

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I. Plant Diseases of 1909—Pages 620-622.
II. Potato Spraying Experiments of 1909—Pages 622-629.

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*In cooperation with Bu. An. Ind. U. S. Dept. Agr.

BULLETIN 154: COMMERCIAL FERTILIZERS SOIL CLASSIFICATIONS AND ADAPTATIONS

By J. L. HILLS, C. H. JONES and P. A. BENEDICT

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SUMMARY

III. Results of inspection. The Station has drawn from dealer's stocks and analyzed all of the licensed brands, 152 in number, the output of 14 companies, all this year's goods.

1. Quantity of plant food. Ninety-one percent of the brands met their guaranties. Not a single brand failed to afford a commercial equivalent of its promises, the best outcome in years.

2. Quality of plant food. The quality of the crude stock used in furnishing phosphoric acid and potash seemed to be beyond reproach. To be sure an inferential claim, that sulphate of potash was used, is made for three-fifths of the brands, while as a matter of fact only five brands contain any appreciable quantities of sulphate; but this quibble on the part of manufacturers is now well understood. More mineral nitrogen was used than ever before. Even the low grade brands carried it. There seems to be increased usage of organic nitrogen of doubtful availability. Some companies continue to purvey an organic nitrogen which is above suspicion. It is to be deplored that this cannot be said of all companies. Pages 646-660.

IV. Selling prices and valuations. The average selling price was $31.45; the average valuation, $20.57. One dollar in three spent for mixed fertilizers was paid to the manufacturer, railroad, and selling agent for their work, while but two of the three were paid for plant food. But 56 cents'

worth of plant food was bought for a dollar in average low grade goods, and 63 cents' worth in medium grade goods. The average high grade brand, however, afforded 67 cents' worth for a dollar. Some Vermont consumers paid fully twice as much for plant food as did others. Pages 660-668.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 669-691.

VI. A comparison of analyses of brands for five years shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods. Pages 692-702.

VII. Soil classifications are based (1) on origin, (2) on physical characteristics, (3) on usage, (4) according to the scheme of the National Bureau of Soils. The first indicates the method of their formation, the second their nature as to the proportions of sand, clay, etc., the third gives a view of soil uses, while the last-named is based on the results of extensive soil surveys.

Soil adaptations are determined by many factors, prominent among which are the proportions of the soil particles of various sizes (classification 2); and the method of soil formation and deposition (classification 1). Soil surveys (classification 4) being made by actual personal visitation to and study of the soils by experts, are of much service in the determination of crop adaptations. Pages 703-731.

VIII. Inasmuch as several technical terms are unavoidably used in the article on soil classification, a glossary is furnished on pages 733-739.

IX. The bulletin is thoroughly indexed on pages 740-742.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletins of the Station dealing with commercial fertilizers shall not only give the results of the analyses of these goods, but shall also publish "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." Usually two bulletins are issued each spring, in April and in June or July. The first gives the analyses of about 60 brands, the valuation schedule, a discussion of its use, a table of analyses for five years, etc.[1] The second discloses the analyses of all the brands collected, shows their composition during the past five years, contains a general review of the trade of the State, makes statements as to the quantity and quality of the plant food sold in the sundry brands, considers the comparative values of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.

These general matters are annually reviewed. In addition thereto, in the second and larger bulletin there is yearly presented a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99, 130, and 143 as well as in this issue. These glossaries will be added to from time to time in the future. Anyone failing to grasp the meaning of terms other than those defined in the glossary in this issue used should get 99, 130 or 143 and make use of their glossaries. They are free for the asking. The larger bulletin is always thoroughly indexed.

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[1] Omitted this year.

The following statement outlines the "features" of the preceding bulletins. The table of contents on pages 635-637 serves to introduce the reader to the matter contained in this issue.

Bulletin 93 (1902). *Formulas for home mixing.*—56 pages).

Bulletin 99 (1903). *Vermont's usage of fertilizers. Concerning fertilizer buying. Deficient plant food.*—(88 pages).

Bulletin 108 (1904). *Classification of commercial fertilizers sold in Vermont. Farm manures.*—(68 pages).

Bulletin 116 (1905). *How, when and what to use.*—(104 pages.) (Available only as a loan).

Bulletin 123 (1906). *Concerning the purchase of plant food. The moisture relations of the soil* (68 pages). (Available only as a loan).

Bulletin 130 (1907). *Soil biology in its relation to fertilization.* (144 pages). (Available only as a loan).

Bulletin 135 (1908). *A quarter of a century of fertilizer inspection. Soil deterioration and soil humus.*—(128 pages).

Bulletin 143 (1909). *The service of a fertilizer control. Soil physiography.*—(144 pages).

These articles were written in 1902, 1903, 1904, 1905, 1906, 1907, 1908 and 1909; but they are just as applicable to the purchase and use of fertilizers in 1910 and succeeding years as they were when first penned. The reader of this bulletin who does not own a 93, a 99, a 108, a 135 or a 143, and wants either or all of them, has but to ask to receive. Nos. 116, 123 and 130, being nearly exhausted, are only issued on loan to those who will promise to return them after they have served their purpose. Circular No. 1—free for the asking—outlines all these bulletins except No. 143.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate ingredients used to manufacture the same, or * * * bone meal, land plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.)

It provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in distilled water, and of soluble, reverted, insoluble, available and total phosphoric acids, and the maximum percentage of chlorin." (Sec. 4976 P. S.)

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) " * * * shall annually * * * pay * * * a license fee of one hundred dollars," which will permit "the sale of not more than five brands of commercial fertilizer, which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than this number of brands, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of five." The fee(s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S.)

It provides that any person offering unguarantied, overguarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the state treasurer, and for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs.

4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.).

The full text will be furnished on application.

LIST OF LICENSEES

The following companies have paid licenses as required by law on the brands shown in the statement on pages 669-674 and in the tables on pages 675-691. The sale within the State of these brands, and of these brands only, is legal. All local agents as well as intending purchasers are warned against the handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the one hundred dollars license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 2 Rector St., New York, N. Y.
Armour Fertilizer Works, 861 Calvert Building, Baltimore, Md.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
J. F. Bromley, Granville, N. Y.
Buffalo Fertilizer Co., William St., near city line, Buffalo, N. Y.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 24-26 Stone St., New York, N. Y.
Essex Fertilizer Co., 39 No. Market St., Boston, Mass.
Lister's Agricultural Chemical Works, Newark, N. J.
Lowell Fertilizer Co., 44 No. Market St., Boston, Mass.
New England Fertilizer Co., 42 No. Market St., Boston, Mass.
Parmenter & Polsey Fertilizer Co., 40 No. Market St., Boston, Mass.
Rogers & Hubbard Co., Middletown, Conn.
Sanderson Fertilizer and Chemical Co., New Haven, Conn.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 69 towns and villages in Vermont during the spring of 1910 and drew 305 samples from dealers' stocks, representing 152 distinct brands, the output of 14 companies licensed to sell in Vermont. A sample was secured of every brand which was licensed.

SCHEDULE OF TRADE VALUES

The following schedule of trade values to be used in this State in 1910 is the one agreed upon by the Experiment stations of New England and New Jersey, after a careful study of prices ruling in the larger markets. The 1909 schedule is also shown for purposes of comparison.

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS FOR 1909 AND 1910

	1909 cts. per lb.	1910 cts. per lb.
Nitrogen in nitrates	16½	16
Nitrogen in ammonia salts	17	16
Organic nitrogen in dry and fine ground fish, blood and meat and in mixed fertilizers	19	20
" " in fine ground bone and tankage	19	20
" " in coarse bone and tankage	14	15
Phosphoric acid soluble in water	4	4½
" " soluble in ammonium citrate[1]	3½	4
" " in fine ground bone and tankage	3½	4
" " in coarse bone and tankage	3	3½
" " insoluble (in water and in ammonium citrate[1]) in mixed fertilizers	2	2
Potash as high grade sulphate and in mixtures free from muriate (chlorid)	5	5
Potash as muriate	4¼	4¼

These trade values are, as nearly as can be estimated, the average figures at which, in the six months preceding March 1st, the respective ingredients could be bought at retail for cash in the larger markets (Boston, New York, etc.), in the *raw materials*, unmixed. They also correspond to the average wholesale prices for six months ending March 1st, plus about 20 percent in the case of goods for which there are wholesale quotations. The valuations obtained by the use of the above figures will be found to agree fairly with the reasonable average retail price in the large markets of standard raw materials.

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[1] Dissolved from 2 grams of the prepared sample, previously extracted with pure water, by 100 c. c. of a neutral solution of ammonium citrate, sp. gr. 1.09, in 30 minutes at 65 degrees C, with agitation once in five minutes.

In applying trade values to mixed goods, organic nitrogen is valued at 20 cents a pound; nitrogen as nitrate of soda and as sulphate of ammonia at 16 cents a pound; soluble, reverted and insoluble phosphoric acid at 4½, 4 and 2 cents a pound respectively; and potash at 4¼ cents a pound, if there is sufficient chlorin to unite with all the potash; if not, it is valued at 5 cents.

A valuation is determined as follows: The percentages or pounds per hundred of each ingredient (i. e., nitrate nitrogen, ammoniacal nitrogen, organic nitrogen, soluble phosphoric acid, reverted phosphoric acid, insoluble phosphoric acid and potash), are multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

THE MEANING OF COMMERCIAL VALUATIONS

That there may be no misconception and that the reader may clearly appreciate what these valuations are and what they are not, it is our custom to call attention repeatedly to the fact that *a station valuation does not represent the proper selling price of a fertilizer at the point of consumption.* Neither should it be inferred that the ingredients in the brand in question have of necessity the commercial value indicated. It may be greater or less than is shown. The Station does not pretend dogmatically to state what may be the commercial worth or valuation of any one of the many brands of fertilizer sold in the Vermont market, as it cannot always affirm the quality of the crude stock used, particularly the nitrogenous material. The valuation system is based on the assumption that all brands are composed solely of high grade ingredients, an assumption which is probably erroneous. "Valuations" should not be construed as showing the commercial worth of a given fertilizer, but the *retail trade value or cash-cost of amounts of nitrogen, phosphoric acid and potash, equal to those contained in a ton of the brand in question, in unmixed, standard raw materials of good quality, at the seaboard.* They bear no necessary relationship to the agricultural or the crop producing value of the goods, but simply indicate the current market prices of standard commercial articles, more particularly nitrate of soda, sulphate of ammonia, dried blood, tankage, ground bone, acid phosphate, muriate of potash, sulphate of potash and kainit.

Valuations thus construed, while not infallible, are helpful:

(*a*) To show whether a given fertilizer is worth its cost from the *commercial* standpoint.

(*b*) As a common basis on which to compare the *commercial* values of different brands, enabling buyers to note whether prices asked are warranted by values contained.

Valuations, then, simply show the cost of ready-made plant food. Its cost, however, is but one of the many charges which determine the retail cost of commercial fertilizers, just as the leather from which a pair of shoes is made is but one of the many charges which go to make up the retail cost thereof. The plant food must be also mixed, stored, reground, bagged, loaded, and freighted. Then too, commissions to agents and dealers, the expense of selling on long credit, the item of bad debts, the interest on investments, the depreciation of the manufacturing plant, profits, etc., are also proper and fixed charges; yet not one of these so-called "overhead charges" contributes to plant growth. Commercial fertilizers are usually applied in the mixed form, but this is simply a matter of convenience, for as good results may be obtained by the separate application of the crude ingredients.

An illustration may serve to make these statements more clear. A farmer buys in Boston or New York 50 pounds of nitrate of soda, 350 pounds of dried blood, 1,475 pounds of acid phosphate, and 125 pounds of muriate of potash, and he mixes these ingredients together at home on his barn floor, as thousands have done before him. The cost of this ton after mixing will be made up as follows: (*a*) Cost of material in the market; (*b*), cost of transportation; (*c*) cost of mixing. The first item (*a*) entering into the total cost is the only one included in the "valuation." If to (*a*) be added (*b*), (*c*), and, also, the expenses of selling through agents, long credits, bad debts, etc., we have the factors involved in the cost of fertilizers delivered in Vermont. Clearly the local selling price must of necessity exceed the "valuation." Since the cost of mixing and selling varies with different companies, and since freight rates to the different sections of the State are unlike, no arbitrary sum to cover these charges can be assigned. These can be estimated best by the consumer to fit his local conditions. He should expect to pay and does pay not only for the plant food contents of his purchase, but also a fair margin to cover the expenses incident to assemblage, manufacture and sale, as well as for the convenience and other advantages pertaining to the use of ready-made and locally supplied plant food. If the selling price does not exceed the valuation by more than 35 or 40 percent it may not be too high, but in proportion as the excess increases beyond this point there is reason to question the economy of the purchase. The reader is referred for a further and somewhat full discussion of this matter to pages 81-86 of bulletin 99, also to the special article in bulletin 143, pages 183-192, dealing with the exposition of the meaning of the analyses and valuations. Either or both of these bulletins will be sent without charge on request.

III. RESULTS OF FERTILIZER INSPECTION

1. AS TO QUANTITY OF PLANT FOOD

(*a*). COMPARISON OF GUARANTIES AND ANALYSES

The general quality of the brands sold in 1910 was better than in any previous year save 1903. Only 14 out of 152 brands were found wanting; half of this number were but very slightly short in a single ingredient; and not a single brand failed to carry the commercial equivalent of its guaranty. This is a most gratifying statement to make in a year when a much larger number of brands than hitherto have been sold. It is in strong contrast with the results attained two years ago, when nearly one brand in three was lacking in some respect, when six brands failed to furnish a commercial equivalent of its plant food promises, and a case was reported to the State's attorney for prosecution.

The plant food shortages in the deficient brands were distributed as follows. Nitrogen 1, available phosphoric acid 9, potash 5. Only one brand was short in two ingredients; but in that case the shortage totalled but 0.60 percent or barely 3 percent of the entire promised plant food; and the deficiency was amply made good commercially by an excess of nitrogen. In short, of the 446 guaranties made on 152 brands but 6, or 1 in 75, were in excess of 0.50 percent, and but 2, or 1 in 225, in excess of 0.75 percent. A better result could hardly be desired.

Whenever guaranties were not made good the analytical work was repeated, and, invariably recourse was had to other samples, taken a second time from the original shipments, except in cases where the goods were used prior to the determination of the shortage. In several cases when results seemed open to question, other samples were elsewhere drawn. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were also instituted with a view of minimizing error and standardizing results. This general procedure has been in vogue at this Station for years, and is thought to minimize to the last degree the likelihood of error in sampling or analysis.

The condensed results of 16 years' inspection of the Vermont fertilizer trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1895	92	76	16	83	95
1896	110	91	19	83	99
1897	134	113	21	84	94
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	93	38	71	94
1906	130	110	20	85	98
1907	129	98	30	77	94
1908	130	92	38	71	95
1909	133	111	22	83	96
1910	152	138	14	91	100

The table on the next page shows the number of brands sold by the different companies licensed in the State, the number of guaranties (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good within 0.10 percent of nitrogen or 0.20 percent of available phosphoric acid or potash.

Seven of the fourteen companies contribute brands to the delinquent list. Five furnish a single brand each; one affords two and one seven.

MAINTENANCE OF GUARANTIES BY LICENSEES

Name of company	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands not making good the commercial equivalent of the guaranty
American Agricultural Chemical Co.	5	13	1	0
Bradley Fertilizer Co. branch	12	35	2	0
Clark's Cove Fertilizer Co. branch	3	9	0	0
Cleveland Dryer Co. branch	3	9	0	0
Crocker Fert. and Chem. Co. branch	4	12	1	0
Cumberland Bone Phosphate Co. branch	3	9	0	0
L. B. Darling Co. branch	2	6	0	0
East India Chemical Co. branch	3	9	0	0
Great Eastern Fertilizer Co. branch	4	12	0	0
Pacific Guano Co. branch	3	9	0	0
Quinnipiac Co. branch	4	12	0	0
Read Fertilizer Co. branch	7	20	2	0
Henry F. Tucker Co. branch	3	9	0	0
Williams & Clark Fertilizer Co. branch.	6	18	2	0
American Agricultural Chem. Co.—Total	62	182	8	0
Armour Fertilizer Works	5	14	0	0
Bowker Fertilizer Co.	15	44	0	0
J. F. Bromley	7	21	0	0
Buffalo Fertilizer Co.	7	19	2	0
Burlington Rendering Co.	2	6	1	0
Coe-Mortimer Co.	6	17	1	0
Essex Fertilizer Co.	6	18	0	0
Lister's Agricultural Chemical Works	9	26	1	0
Lowell Fertilizer Co.	9	27	0	0
New England Fertilizer Co.	5	15	0	0
Parmenter and Polsey Fertilizer Co.	6	18	1	0
Rogers and Hubbard Co.	8	24	1	0
Sanderson Fertilizer and Chemical Co.	5	15	0	0
Total	152	446	15	0

The range of composition and the closeness with which guaranties are met are shown in the first table on the next page. The condition of affairs it discloses, a close hugging of the guaranties, has obtained for years, as appears in the second table, which shows the excess of the average analysis over the average guaranty for five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average ten percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

GUARANTIES, ANALYSES, SELLING PRICES AND VALUATIONS

	PERCENT GUARANTIED			PERCENT FOUND			Excess of average analysis over guaranty
	Lowest	Highest	Average	Lowest	Highest	Average	
Nitrogen,	0.8	8.5	†1.99	0.76	8.23	†2.28	0.29
Total phosphoric acid,	5.	16.	9.06	6.28	17.92	9.89	0.83
Avail. phosphoric acid,	4.	11.	7.56	4.14	11.78	8.36	0.80
Potash,	1.	12.	4.66	1.22	12.86	4.99	0.33
Selling price,	$21.50	$59.00	$31.45	....	.....	.....	.....
Valuation,	$10.50	$39.68	$18.39	$10.39	$41.16	$19.85	$1.46

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSIS OVER GUARANTIES

	1906	1907	1908	1909	1910	Av'ge for 5 years
Nitrogen,	0.28	0.20	0.18	0.22	0.29	0.23
Total phosphoric acid,	1.58	1.21	1.24	1.39	0.83	1.25
Available phosphoric acid,	0.67	0.45	0.50	0.59	0.80	0.60
Potash,	0.37	0.35	0.33	0.33	0.33	0.34
Valuation,	$2.47	$1.61	$1.69	$1.86	$1.46	$1.82

While the above statement shows that the goods compare well on the average with the claims made for them, the tables on pages 675-691, as well as the statements on pages 646 and 647, betray the fact that within this average lie concealed a few deficiencies. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guaranteed is not furnished to know that the "average" is good. It is for him to exercise care and to avoid buying such goods. Yet it should be said that this year no *seriously* faulty fertilizers, so far as guaranty maintenance is concerned, were found. Some years, however, very deficient goods have been offered.

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*No nitrogen in 10 brands.

†Non-nitrogenous goods omitted; if included, average drops 0.13 percent in guaranties and 0.16 percent in actualities.

(b) COMPARATIVE VALUES OF FERTILIZERS OF 1909 AND 1910

Of the 155 brands of commercial fertilizers which were sampled by the Station during 1909 and 1910, 129 have been selected for comparison of the characters of the goods sold under these brands in each of the two years. Only those brands have been chosen which have been sampled both years. The comparison shows a gain in all three ingredients in 1910 as compared with 1909, the net increase on a money basis, i. e., valuation, being twenty-five cents. The sharp fall in insoluble phosphoric acid, due perhaps to more complete sulphuric acid treatment at the factory, is the reason why the monetary gain is not larger.

AVERAGE COMPOSITION OF FERTILIZERS IN 1909 AND 1910

Name of ingredient	1909 Pounds in a hundred	1909 Valuation at 1910 prices	1910 Pounds in a hundred	1910 Valuation at 1910 prices
Nitrogen *	2.05	$8.20	2.12	$8.48
Soluble phosphoric acid	5.26	4.73	5.60	5.04
Reverted phosphoric acid	3.09	2.47	2.84	2.28
Insoluble phosphoric acid	2.25	0.90	1.57	0.63
Total phosphoric acid	10.60	....	10.01	....
Available phosphoric acid	8.35	....	8.44	....
Potash †	4.61	3.92	4.75	4.04
Total valuation per ton....		$20.22		$20.47

(c) COMPARATIVE VALUE OF FERTILIZERS FROM 1895 TO 1910

The next table shows the average composition of the fertilizers as analyzed during the past 16 years. Every brand

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*Nitrogen calculated as all organic; although this year very much more mineral nitrogen had been used than ever before and relatively less organic nitrogen. The former has been much the cheaper and the latter relatively scarce.

†Potash calculated as muriate.

tested each year is included in the comparison, each one being given equal value. It is well understood that this is not strictly a correct method of calculation, but it is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods in the past sold slowly, and, unfortunately, low grade brands as a rule readily; the actual average as used is probably somewhat lower than that shown in the table. Yet the evidence in hand indicates a lessened usage of low grades and a larger usage of medium and high grades to-day than formerly obtained.

It ought to be remarked at this point that neither this table, nor the table which immediately precedes it, nor the discussion of this matter, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made in 1904 to estimate the relative usage of the different grades, but without much success. No data is available that is trustworthy, while if one appeals to the individual judgment of those who are in closest touch with the trade, the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used at 1.80 to 1.90 percent nitrogen, 8.50 percent available phosphoric acid, and 3.25 to 3.50 percent potash. That is to say that the relatively larger usage of the low and medium grades and smaller usage of the higher grades which doubtless obtains tends to lower the general average. But there is evidence tending to show yearly an increase in the usage of the higher grades, a tendency which on the whole is to be encouraged.

The average commercial fertilizer sold in Vermont in 1910 contains a little more nitrogen, the same amount of available phosphoric acid, but two-thirds as much insoluble phosphoric acid and nearly a third of a percent more potash than that sold in 1909. The increase in the averages of the past six years,

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1895 TO 1910[1]

Year	Number of brands	Nitrogen	Soluble phosphoric acid	Reverted phosphoric acid	Insoluble phosphoric acid	Total phosphoric acid	Available phosphoric acid	Potash
1895	92	2.22	5.84	2.56	2.23	10.93	8.40	3.46
1896	110	2.22	5.36	3.44	2.23	11.02	8.80	3.66
1897	134	2.12	5.34	3.68	2.23	11.25	9.02	3.43
1898	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81
1899	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10
1900	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80
1901	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33
1902	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21
1903	111	2.02	5.13	3.42	2.50	11.05	8.55	3.97
1904	118	1.98	5.20	3.19	2.38	10.77	8.39	3.95
1905	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18
1906	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37
1907	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65
1908	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58
1909	133	2.08	5.25	3.07	2.21	10.53	8.32	4.70
1910	152	2.12	5.50	2.86	1.53	9.89	8.36	4.99

AVERAGE COST OF FERTILIZERS SOLD IN VERMONT FROM 1895 TO 1910

Year	Number of brands analyzed	Average selling price per ton	Average valuation at each year's trade values	Excess of selling price over valuation	Percentage excess of selling price over valuation	Value of plant food received for each dollar paid out	Average valuation at 1910 trade values
1895	92	$30.90	$21.28	$ 9.62	45	69 cts.	$20.03
1896	110	30.90	19.73	11.17	57	64 "	20.47
1897	134	29.19	19.47	9.72	50	67 "	20.05
1898	126	29.04	17.86	11.18	63	61 "	20.54
1899	137	28.75	17.39	11.36	65	60 "	19.86
1900	132	28.73	18.08	10.65	59	63 "	19.96
1901	134	28.75	19.44	9.31	48	68 "	20.35
1902	136	28.23	20.18	8.05	40	71 "	20.87
1903	111	28.25	18.59	9.66	52	66 "	19.76
1904	118	29.00	18.47	10.53	57	64 "	19.47
1905	130	29.62	19.18	10.58	56	64 "	19.79
1906	130	29.52	19.38	10.14	52	66 "	20.17
1907	129	30.57	21.21	9.36	45	69 "	20.39
1908	130	31.24	20.75	10.49	51	66 "	19.99
1909	133	31.43	18.84	12.59	67	60 "	20.39
1910	152	31.45	20.57†	10.88	53	65 "	20.57

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[1] See statement as to average midway down opposite page.

as compared with those of previous years, is due to the somewhat unusual character of certain goods sold for the first time in 1905, and to the entry in each of several years since of a number of relatively high grade goods. A survey of the table indicates that no profound change has taken place during the fifteen years. Indeed, there seems to be three periods of four, six and six years respectively wherein there are somewhat wide differences in the plant food content of the average goods, particularly in phosphoric acid and potash, as shown below:

1895-98.....nitrogen 2.19, available phosphoric acid 8.75, potash 3.60
1899-04.....nitrogen 2.07, available phosphoric acid 8.51, potash 4.06
1905-10.....nitrogen 2.09, available phosphoric acid 8.24, potash 4.58

The average grade goods are better to-day than hitherto; but that is not saying that there are not many inferior ones on the market.

At what prices did the sundry forms of available plant food sell in the average mixed fertilizer of these years? These data

COST OF PLANT FOOD IN THE AVERAGE MIXED FERTILIZER, 1895 TO 1910

Year	Number of brands analyzed	Cost of one pound of organic nitrogen	Cost of one pound of available phosphoric acid	Cost of one pound of potash (as muriate)
1895	92	23.9 cts.	8.7 cts.	6.5 cts.
1896	110	22.0 "	8.6 "	7.1 "
1897	134	21.0 "	8.3 "	6.8 "
1898	126	22.8 "	7.3 "	6.9 "
1899	137	23.1 "	7.4 "	7.0 "
1900	132	24.6 "	7.1 "	6.7 "
1901	134	23.7 "	7.4 "	6.3 "
1902	136	23.1 "	7.0 "	6.0 "
1903	111	25.9 "	6.8 "	6.5 "
1904	118	27.5 "	6.9 "	6.7 "
1905	130	28.9 "	6.8 "	6.6 "
1906	130	28.3 "	6.6 "	6.4 "
1907	129	29.6 "	6.9 "	6.1 "
1908	130	30.5 "	7.1 "	6.3 "
1909	133	31.7 "	6.3 "	7.1 "
1910	152	31.7 "	6.8 "	6.7 "

are afforded by the table shown at the bottom of the opposite page, from which it is evident that the tendency of late years has been towards increased selling prices. This is particularly true of medium and of high grade goods.

2. AS TO QUALITY OF PLANT FOOD

(*a*) SOURCES OF PLANT FOOD IN LICENSED FERTILIZERS

The table on page 650 as well as those on pages 675-691 show wide ranges in composition, amounts of nitrogen varying from 0.76 to 8.23 percent, of available phosphoric acid from 4.14 to 11.78 per cent, and of potash from 1.22 to 12.86 percent. These figures alone, however, do not tell the whole story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food of the various brands is derived.

NITROGEN

Every licensee used more or less of a mineral form of nitrogen (nitrate of soda or sulphate of ammonia) in one or more of his brands[1] and usually in most of them. Some of the manufacturers have habitually used mineral forms of nitrogen; others have just begun its use. The great divergence between the market prices of mineral and organic nitrogens doubtless in part explains this free usage of the former. More or less mineral nitrogen was present in all but 6 of the brands, which contained nitrogen, the amounts varying from 0.11 to 7.58 percent and averaging 0.91 percent (44 percent of the total nitrogen present in these brands). Under certain circumstances and for certain purposes mineral nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available, but more easily lost by leaching. (See pages 89-90, bulletin 99). All the brands which carry nitrogen contain more or less organic nitrogen, derived, presumedly, as a rule from standard animal and vegetable ammoniates such as dried blood, meat meal, fish scrap, tankage, etc. Probably tankage is at present a main source in a large proportion of the brands.

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[1] One only in minute quantities. It is an open question if any ammonia salts were used, or whether the ammonia found was derived from organic sources.

Available nitrogen.—Every brand carrying organic nitrogen was tested by the alkaline-permanganate distillation method,[1] as has been done yearly for twelve years. This method, as has been pointed out hitherto, affords results which have comparative rather than absolute values.

The subjoined table shows the organic and total nitrogen availabilities of the average goods made by each firm as measured by this method. Each brand is given equal value in the average. The figures are arranged in the general order of their excellence, yet no stress should be laid upon the order of statement. Since the method used is not definitely adopted as official, firm names are omitted and averages only are printed.

Hitherto the permanganate has been used on the organic nitrogen, regardless of whether it was or was not soluble in water. A considerable study of this matter during the past year has suggested a modification of the method and it is now being applied solely to the water-insoluble organic nitrogen. In the subjoined table the availability of such of the organic nitrogen as is insoluble in water was determined, and the total organic nitrogen availability calculated on the basis of 70 percent availability for that which is soluble in water, this proportion being approximately the availability of dried blood as determined by vegetation trials.

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[1] Vt. Sta. Rpts. 11, pp. 160-171 (1898); 12, pp. 137-139 (1899); 14, pp. 219-221 (1901).

AVAILABILITIES (AS MEASURED BY ALKALINE PERMANGANATE) OF

	Water-insoluble nitrogen	Total organic nitrogen	Total nitrogen[1]		Water-insoluble nitrogen	Total organic nitrogen	Total nitrogen[1]
A,	60	64	80	H,	51	57	81
B,	59	64	68	I,	50	58	70
C,	58	64	68	J,	49	58	69
D,	57	63	65	K,	46	55	78
E,	56	64	68	L,	45	53	71
F,	55	62	67	M,	42	52	69
G,	55	60	69	N,	41	54	64

As to grade. The availability of the water-insoluble organic nitrogen used in brands low in that ingredient tended as a rule to be less than that of the brands classed as medium or high grades. The following comparative statements as to the average results obtained with the brands of several companies is evidence of this fact. The order of statement has no significance whatsoever.

AVAILABILITY OF WATER-INSOLUBLE ORGANIC NITROGEN (AS MEASURED BY ALKALINE PERMANGANATE) IN

	Low grade brands	Medium grade brands	High grade brands
	45	47	48
	45	48	56
	42	49	53
	46	55	61
	53	57	60
	56	56	62
	37	50	46
	34	..	55
	37	52	62
Average	44	52	56

Speaking broadly, the water-soluble inorganic nitrogen purveyed in the low grade goods as a class seems not only to be lacking in quantity but also to be lacking in quality.

As to manufacture. The station records for a dozen years touching this matter of organic nitrogen availability are a most interesting study. Year after year the goods of certain companies, as a whole, group at the top of the list; year after year others, as a whole, tend to huddle together towards its foot. There is every reason to believe that this outcome is not due to coincidence, but to definite causes. During the past two seasons the analytical results have been in a considerable number of cases quite unsatisfactory. Yet the outcome with several companies, as has always been the case, was all that could be desired. A possible explanation of the increased number of brands rating low in this respect was advanced in last year's bulletin, it being there ascribed to "the high cost, restricted supply, and heavy demands for standard organic ammoniates, together with the marked increase in total sales of mixed goods." This year supplies seem to be even more restricted ,and the sales of mixed goods are said to be larger than ever before. About all that the writer deems it desirable to say at present touching this matter is that he gravely doubts whether some of the organic nitrogen sold to Vermont farmers this year will be likely to prove worth anywhere near what it costs them. A further and more extended study of this general proposition is in progress in the laboratory.

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[1] Nitrogen as nitrate or as sulphate of ammonia included as 100% available.

PHOSPHORIC ACID

Some companies furnish more total phosphoric acid in available form than do others; some, more of the water-soluble relative to the citrate-soluble or reverted than do others. Water-soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate-soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumina phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as valuable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 57 percent to 95 percent. The proportions of available phosphoric acid found to be in a water-soluble form varied from 4 percent to 85 percent. Grouped according to their manufacture it was found that extremes for available in total were 69 and 90 percents, for water-soluble in available 28 and 75 percents. In other words, the average goods made by one firm carried 90 percent of the total phosphoric acid in available form, while those made by another firm furnished but 69 percent in that shape, the remainder ranging between. Similarly, on the average 75 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 49 percent was thus soluble in the average goods of another firm. The low availability seems to be due in some cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause, to imperfectly cut phosphate rock, to the age of the goods, to the use of agriculturally inferior forms of phosphoric acid, or to other causes, does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, very rarely, nitrate. The direct or inferential claim is made for two-thirds of the brands that sulphate of potash is used in their manufacture. This is usually merely a subterfuge, is intentionally misleading, and is not borne out by the facts. It is doubtless not illegal for a manufacturer to indicate an equivalence, since such an expression is not strictly speaking a guaranty, but simply a part of that surplusage with which manufacturers are apt to bedeck fertilizer sacks. Seven of the fourteen companies selling in Vermont do not try thus to mislead their customers; seven, however, for some or all their goods made this doubtful statement. The American Agricultural Chemical Company makes this inferential claim by the use of the phraseology "equivalent to sulphate of potash," for the entire 62 brands; the Bowker Fertilizer Company, for 15 brands;

the Lister Company for 8 of 9 brands; the Lowell Fertilizer Company, for 8 of 9 brands; the Burlington Rendering Company, for 1 of 2 brands; the New England Fertilizer Company for 4 of 5 brands; the Sanderson Company for 3 of 5 brands. Oddly enough for the five brands in which it is used, three largely and two slightly, no claim of sulphate is made. Either it is not used in a single one of the 98 brands whose makers intimate its use; or else enough chlorin is present therein in each case to neutralize its good effects, if any such there be. Only three brands out of the entire 152 carried any material quantitites of sulphate of potash. Wherever the asterisk (*) or the dagger (†) appears against the station number at the left of the analysis and against the potash figures in the columns thus headed in the tables on pages 675-691, sulphate (or, possibly, nitrate) of potash was found to be present; where these signs do not appear the potash was derived from muriate or kainit.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for nearly 15 years. It has been customary of late to approach the matter from two directions, to make two classifications, basing one on *cost* and the other on *value*. Three groups, somewhat arbitrarily formed, designated "low priced," "medium priced" and "high priced," furnish the means of comparing the cost, while as many groups termed "low grade," "medium grade" and "high grade" serve the purpose in the study of relative values.

When grouped according to selling prices the item of *cost* is emphasized; when the valuations govern the sub-divisions, the stress is laid upon the *worth* of the material. The selling price may or may not bear an essentially just relation to the plant food content of the fertilizer. The valuation, however, is a more exact measure. Since both cost and worth are important factors, and since some may grasp the facts more readily when rom one viewpoint while others see the situation bet- oked at from the other side, it has been deemed best the results of both methods of comparison. The tcome is much the same either way the proposition is

I. FROM THE STANDPOINT OF COST

rands may be classified as to selling price as follows:

	Number of brands	Percent of total	Average selling price
selling at $28 or below....	42	28	$26.14
iced, selling from $28.50 to	65	43	29.95
l, selling for $33 or more...	43*	29	38.23

verage, largest and smallest values of plant food of- e groups of brands appear below. The figures show of plant food bought for a dollar in the average goods ade, including the greatest as well as the least value any brand in each class.

VALUE OF PLANT FOOD BOUGHT FOR A DOLLAR

	Average	Smallest	Largest
l	$0.56	$0.45	$0.70
iced	0.63	0.45	0.76
d	0.67	0.55	0.76

interesting to note the number of brands in each group nish less than 55 cents' worth of plant food[1] for a dol- ll as the number which afforded more than 65 cents' the same sum:

l:	Less than 55c. worth, 16; more than 65c. worth, 1
iced:	Less than 55c. worth, 8; more than 65c. worth, 24
d:	Less than 55c. worth, 0; more than 65c. worth, 30

comparisons can be shown graphically. The relative the following lines show the average money value in l at retail seaboard prices bought for a dollar at Ver-

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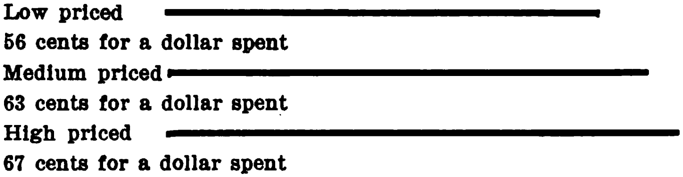
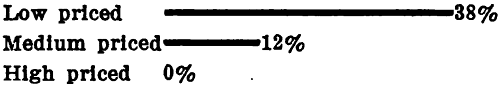
hly nitrogenous and relatively costly oats and topdressing and a tobacco goods are omitted from the comparison.

rase "55 cents' worth of plant food" should be construed to mean of plant food which, if bought for cash at retail at the seaboard, cost 55 cents in standard, unmixed, raw materials.

mont delivery points in brands selling for $28 or less, (low priced), from $28.50 to $32.50 (medium priced), and for $33 and above (high priced):



The following lines show the proportion of the total number of brands in each group containing 55 cents or less worth of plant food for each dollar invested:



The final set of lines show the proportion of the total number of brands in each group containing 65 cents or more worth of plant food for each dollar invested of the purchase price:

If lines and figures are put into words, it will be seen that:

1. The same amounts of plant food which cost a dollar in the average low priced brands ($28 and below) might have been bought in the unmixed state at retail and at the seaboard for 56 cents; in the average medium priced goods ($28.50 to $32.50) for 63 cents; and in the average high priced goods ($33 and upwards) for 67 cents. Extremes of values were 76 and 45 cents. In one-sixth of the brands the sums charged for manufacture, transportation, sale, etc., comprised 45 percent or more of the retail cost, thus leaving only 55 percent or even less to pay for the plant food; while in eleven brands these charges equalled or exceeded the seaboard value of the unmixed plant food.

2. In three-eighths of the total number of low priced brands the charges for mixing, sale, etc., aggregated at least 45 percent

ing price, while in only one in eight of the number priced brands and in not a single one of thirty-eight goods were the charges thus large.

wo-thirds of the total number of high class goods con- equivalent of 65 cents or more worth of plant food aboard prices. But three in eight of the medium and le brand in forty-two low grade goods contained so quivalent.

things are naturally so, inevitably so. There are sufficient reasons for this showing, which may be con- a nutshell as follows: It costs as much to mix, to regrind, to bag, to ship, to freight, to sell, to collect etc., a ton carrying 1,200 pounds of genuine fertil- 800 pounds of mere filler (diluent) as one that con- pounds of undiluted fertilizer ingredients. Therefore of low grade goods must pay for all this useless hand- ie nearly or quite worthless filler. It is an old story, year after year, but it is one which needs to be told s material usage of low grade brands obtains.

2. FROM THE STANDPOINT OF VALUE

us now turn the matter about and study it from the t of *worth*. The figures and proportions naturally dif- those just presented. The brands may be classified as ion as follows:

	Number of brands	Percent of total	Average valuation
, valuing at $15.50 or less......	33	22	$13.24
ade, valuing at $15.51 to $22....	72	48	18.57
e, valuing at $22.01 and upwards.	45	30	25.90

composition, selling price and valuation[1] of the average each group appears in the table heading the next page.

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ive of two brands, a highly nitrogenous and relatively costly oats sing, and a high priced tobacco goods, the valuations of which are ery high.

	Nitrogen	Available phosphoric acid	Potash	Total plant food, pounds	Average selling price	Average valuation	Selling price exceeds valuation by
Low grade,	0.98	8.78	2.40	12.2	$26.23	$13.24	$12.99
Medium grade,	1.89	8.78	3.71	14.4	29.25	18.57	10.68
High grade,	3.14	7.46	8.74	19.3	37.78	25.90	11.88

A survey of this table indicates that:

1. The proportion of nitrogen increases in regular graduations from group to group; that of phosphoric acid drops one and one-fourth percent from the lower and medium to the high grade goods; while the potash increases one and one-third percent in the medium and nearly six and one-half percent in the high grade brands, as compared with the lower ones.

2. The low grade goods carry nine times as much phosphoric acid as they do of nitrogen and nearly four times as much phosphoric acid as they do of potash. These proportions become, roughly, four and two in the medium grade. In the high grade fertilizers there are but two and one-third times as much phosphoric acid as nitrogen, and one and one-third percent more potash than phosphoric acid. The latter grade more closely resembles the proportions commonly present in the crops ordinarily grown than do either of the other grades.

3. The medium grade goods for one-ninth advance in price over the cost of the low grade brands offer one-fifth more plant food and two-fifths more commercial value.

4. The high grade fertilizers for three-sevenths advance in price over the cost of the low class goods furnish nearly three-fifths more plant food and almost double the commercial value.

5. The higher the grade the less the margin between cost and worth, both actually and relatively. In buying the average low grade brand, one paid this year $12.99 for service of one sort or another (factory and office charges, freight, selling ex-

c.) incurred in the delivery of $13.24 worth of plant en medium grade goods were bought, $10.68 service laced $18.57 worth of plant food in the buyer's hands; high grade goods are bought $11.88 service charges 5.90 worth of plant food in the buyer's hands. Or, the matter another way,

OF PLACING A DOLLAR'S WORTH OF PLANT FOOD IN THE FARMER'S HANDS WAS:

low grade goods ....98 cents
medium grade goods ....57 cents
high grade goods ....46 cents

ıy be worth while now to scan the prices paid for a nitrogen, of available phosphoric acid and of potash eral grades. The next table shows this, including the owest and highest costs as well as the retail cash cost ıgredients in Boston or New York, or, in other words, ıations." (See pages 643-646 this bulletin, and pages etin 99).

ı POUND OF PLANT FOOD IN FERTILIZERS OF VARIOUS GRADES[1]

	NITROGEN			AVAILABLE PHOSPHORIC ACID			POTASH		
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
	35.8	44.4	28.6	7.8	9.6	6.2	7.6	9.4	6.1
	31.8	44.4	26.4	6.9	9.6	5.7	6.8	9.4	5.6
,	29.8	36.4	26.4	6.5	7.9	5.7	6.3	7.7	5.6
,	20	....	....	4.33	...	...	4.25	...	...

ve of brands mentioned in footnote on page 650.

The same lesson enforced in a different way, that cheap fertilizers are the most costly. Some Vermont buyers paid 44½ cents for a pound of nitrogen which they might have bought for 26½ cents laid down at their doors in mixed fertilizers. They paid under similar circumstances 9½ cents a pound instead of 5¾ cents for phosphoric acid and 9½ cents for potash instead of 5½ cents. They paid almost double prices because they did not give the matter attention, or, perhaps, because they did not believe in "book farming." The thoughtful buyer of high class goods, sold at not overhigh prices, bought plant food at figures not much in advance of valuations plus freight rates.

It ought to be said in this connection that the same brands similarly named, in different localities, as well as the same goods variously named in one locality or, indeed, in one dealer's hands, are sometimes found to sell at different prices, and, apparently, without good reason. A few exorbitant charges have been noted. Moreover, purchasers often fail to exercise good judgment in their choices and pay overhigh charges owing to lack of information as to what to buy and how to buy it. That this situation is largely their own fault can justly be claimed, since the State has thrown about this trade safeguards which are lacking with almost every other class of traffic. The yearly fertilizer inspection, the publication of the results of the work, the free distribution of the bulletins, the clear and concise statements as to the brands on sale, the simplicity and directness of the few fundamental facts which are the main guides as to choice and to purchase; all these are ample justification of the statement that, speaking in general terms, he who is dissatisfied with the results attained with fertilizers has himself to thank for it. This dissatisfaction may be due to unwise choice, that is to say the purchase of a goods ill-adapted to a specific purpose; or, it may arise from the realization that one has paid an unreasonably high price in view of the grade of the goods. In either case a repetition of the experience may be avoided by the exercise of a little care as to choice. Particularly in the matter of purchase there often appears to be but little relation between price and plant food content. Thus, for example, goods guaranteed to carry uniform available phosphoric acid contents, but the highly variable nitrogen and potash contents noted below have been found in recent years selling at a uniform price at points where freight rates were not materially unlike:

Nitrogen, 33 lbs.;	potash, 40 lbs.;	nitrogen and potash, 73 lbs.
Nitrogen, 41 lbs.;	potash, 30 lbs.;	nitrogen and potash, 71 lbs.
Nitrogen, 16 lbs.;	potash, 80 lbs.;	nitrogen and potash, 96 lbs.
Nitrogen, 41 lbs.;	potash, 60 lbs.;	nitrogen and potash, 101 lbs.

Occasionally two brands of the same make with identical nitrogen and phosphoric acid guaranties but with different potash guaranties (1.5 and 3 percents) are found sold at a flat price. That is to say a local agent will offer a corn fertilizer at $30 and a potato phosphate at $30, each containing equal amounts of nitrogen and phosphoric acid, but the latter twice as much potash as the former. This is no sin; neither is it against the law. But what well-informed buyer would choose the corn goods in preference to the potato brand? This situation is less common this year than formerly.

Identical but differently named goods were sometimes sold by one and the same agent at different prices. Again, two brands with similar nitrogen and phosphoric acid guaranties but different potash figures were sold by the same agent at different prices, the higher price being asked for the lower guarantied goods.

The non-nitrogenous brands, ten of which are licensed, being relatively cheap are quite popular and somewhat widely sold. As a class they carry costly plant food. As sold this year in this State they average to offer only 53 cents' worth of plant food for a dollar. When one has ample home supplies of nitrogen, non-nitrogenous goods may prove advisable purchases; but commercially they are usually expensive plant food.

3. AS BETWEEN MANUFACTURERS

One company averaged to charge 50 cents for placing a dollar's worth of plant food in the buyer's hands. Yet another asked

82 cents for the same service. In the one case a dollar bought 67 cents' worth of plant food, in the other 55 cents' worth. For two-thirds of the brands offered by each of two companies was asked from 80 cents upward, for the laying down of a dollar's worth of plant food at the buyer's depot; or stating it another way, the buyer of their low priced brands paid from $1.82 to $2.23 and received therefor a dollar's worth of plant food. His neighbors paid in some cases as low as $1.33 for a dollar's worth. Which made the wiser purchase? It is not difficult for anyone to apply this test before purchase. Thus, for example: Selling price, $30; guaranty, nitrogen 2%; soluble, reverted and insoluble phosphoric acids, 6, 3 and 1%s; potash, 3%; 2 x 20 x .20=8.00.[1] 6 x 20 x .045=5.40. 3 x 20 x .04=2.40. 1 x 20 x .02=0.40. 3 x 20 x .0425=2.55. $8.00 ÷$5.40+$2.40+$0.40+$2.25=$18.75. 18.75÷30=63[2]; or 30 ÷18.75=1.67[3]. Sixty-seven cents' service charge for a dollar's worth of plant food. Sixty-three cents' worth of plant food for a dollar spent.

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[1] I. e., 2% (or 2 pounds per 100) nitrogen, multiplied by the trade value of a pound of nitrogen (20 cents) affords the valuations of the guaranty of nitrogen, $8.00. The other calculations are similarly made.

[2] Valuation divided by cost equals worth of plant food per dollar spent.

[3] Cost divided by valuation indicates service charge paid for a dollar's worth of plant food bought.

III. OBSERVANCE OF THE FERTILIZER LAW

The following companies have paid licenses on the brands specified. The list also shows the points at which samples were drawn and the laboratory sample numbers, referring to the analyses on page 675-691.

AMERICAN AGRICULTURAL CHEMICAL CO., 2 Rector St., New York, N. Y.

E 16. *Grass and Lawn Topdressing;* Bennington.
K 2. *Grass and Oat Fertilizer;* Springfield.
E 14. *High Grade ten percent Manure;* Putney.
E 15. *Northwestern Challenge Crop Producer;* Richford.
K11. *XXX Phosphate and Potash;* Burlington.

(Bradley Fertilizer Co. brands.)

K 1. *Alkaline Bone and Potash;* Sheldon.
E. 13. *Complete Manure for Potatoes and Vegetables;* Bennington.
A 7. *Complete Manure with Ten Percent Potash;* Ludlow.
A 2. *Corn Phosphate;* Sheldon.
E11. *Eclipse Phosphate;* Richford.
E12. *Green Mountain Special;* Brattleboro.
A 8. *High Grade Manure for Potatoes and Roots;* Brattleboro.
A 3. *Niagara Phosphate;* Groton.
A 4. *Potato Fertilizer;* Vergennes.
A 6. *Potato Manure;* Chester.
A 5. *Vermonter for all Crops;* Sheldon.
A 1. *XL Superphosphate of Lime;* Vergennes.

(Clark's Cove Fertilizer Co. brands.)

H 7. *Bay State Fertilizer G. G.;* East Barnard.
H 8. *King Philip Alkaline Guano;* South Royalton.
H 6. *Potato Fertilizer;* Underhill.

(Cleveland Dryer Co. brands.)

B 7. *Fertilizer for all Crops;* Enosburg Falls.
B 6. *Potato Phosphate;* Enosburg Falls.

B 5. *Superphosphate;* Sheldon Junction.

(*Crocker Fertilizer and Chemical Co. brands.*)

B 3. *Ammoniated Corn Phosphate;* East Montpelier.
B 4. *New Rival Ammoniated Superphosphate;* Springfield.
B 2. *Potato, Hop and Tobacco Phosphate;* Springfield.
B 1. *Special Potato;* St. Albans.

(*Cumberland Bone Phosphate Co. brands.*)

H 4. *Guano;* Waterbury.
G 1. *Potato Fertilizer;* Johnson.
H 5. *Superphosphate;* Johnson.

(*Darling Fertilizer Co. brands.*)

H10. *Farm Favorite;* Fairlee.
T13. *General Fertilizer;* Royalton.

(*East India Chemical Co. brands.*)

B 8. *Complete Potato Manure;* Ludlow.
E 8. *Harvest Home Fertilizer;* Royalton.
H 3. *Standard UnXlD Fertilizer;* Jericho.

(*Great Eastern Fertilizer Co. brands.*)

F10. *Garden Special;* East Hardwick.
E 7. *General Fertilizer;* North Danville.
F 9. *Northern Corn Special;* East Hardwick.
E 6. *Potato Manure;* Newfane.

(*Pacific Guano Co. brands.*)

H11. *Nobsque Guano;* Newport.
B10. *Potato Special;* Brattleboro.
B 9. *Soluble Pacific Guano;* Burlington.

(*Quinnipiac Co. brands.*)

H 12. *Climax Phosphate;* Montpelier.
B13. *Corn Manure;* Putney.
B12. *Market Garden Manure;* Brattleboro.
B11. *Potato Phosphate;* Ludlow.

(*Read Fertilizer Co. brands.*)

G 9. *Farmers' Friend Superphosphate;* Cambridge.
H13. *High Grade Farmers Friend Superphosphate;* Warren.
H14. *Leader Blood and Bone;* South Northfield.

J 10. *Potato Manure;* St. Albans.
B 14. *Practical Potato Special;* Bridport.
F 16. *Standard Superphosphate;* Hardwick.
K 9. *Sure Catch Fertilizer* · Sudbury.

(*H. F. Tucker Co. brands.*)

G 7. *Imperial Bone Superphosphate for all Crops;* Jonesville.
B 13. *Imperial Bone Superphosphate for Corn;* Ludlow.
B 16. *Imperial Bone Superphosphate for Potatoes;* Ludlow.

(*Williams & Clark Fertilizer Co. brands.*)

C 1. *Americus Corn Phosphate;* Middlebury.
C 3. *High Grade Special for Potatoes;* Brattleboro.
C 4. *Americus Potato Manure;* Brattleboro.
H 15. *Potato Phosphate;* Barre.
H 16. *Prolific Crop Producer;* Montpelier.
C 2. *Royal Bone Superphosphate for all Crops;* Swanton.

ARMOUR FERTILIZER WORKS, 861 Calvert Building, Baltimore, Md.

H 1. *Complete Manure;* Bellows Falls.
G 16. *Corn Special;* South Londonderry.
J 6. *General Farm;* Pownal.
G 15. *High Grade Potato;* South Londonderry.
K 10. *Oats and Clover Special;* Pownal.

BOWKER FERTILIZER CO., 43 Chatham St., Boston, Mass.

A 10. *Corn Phosphate;* Sheldon.
F 2. *Early Potato Manure;* Castleton.
F 4. *Hill and Drill Phosphate;* Castleton.
F 4. *Market Garden Fertilizer,* Castleton.
F 3. *Potash Bone;* Glover.
A 13. *Potash or Staple Phosphate;* Enosburg Falls.
H 2. *Potato and Vegetable Fertilizer;* Williston.
A 12. *Potato and Vegetable Phosphate;* Enosburg Falls.
F 6. *Square Brand Bone and Potash;* Sharon.
A 14. *Stockbridge Manure for Corn and Grain;* Bristol.
A 15. *Stockbridge Manure for Potatoes;* Bristol.

A16. *Stockbridge Manure for Quick Growth (Topdressing):* Barton.

K 6. *Superphosphate with Potash;* Enosburg Falls.

A11. *Sure Crop Phosphate;* Enosburg Falls.

A 9. *Vermont Grange Chemicals, D. Brand;* Bristol.

J. F. BROMLEY, Granville, N. Y.

C 5. *Banner Brand;* Montpelier.

F 1. *Corn and Potato;* East Berkshire.

K 7. *Grain and Grass;* East Berkshire.

C 9. *Green Mountain Brand;* Sheldon.

C 8. *Potato Special;* Brandon.

C 7. *Special Corn Fertilizer;* Sheldon.

C 6. *Special Potato Fertilizer;* Brandon.

BUFFALO FERTILIZER CO. William St. near city line, Buffalo, N. Y.

C16. *Celery and Potato Special;* Mount Holly.

K 4. *Extra Bone and Potash;* St. Albans.

C14. *Farmers Choice;* St. Albans.

C12. *Fish Guano;* St. Albans.

K 5. *General Crop;* Plainfield.

C15. *High Grade Manure;* Whiting.

C13. *Ideal Wheat and Corn;* Plainfield.

BURLINGTON RENDERING CO., North Avenue, Burlington, Vt.

D 1. *Animal Fertilizer;* Middlesex.

D 2. *Special Potato Fertilizer;* Franklin.

COE-MORTIMER CO., 24-26 Stone St., New York, N. Y.

C11. *Columbian Corn and Potato Fertilizer;* Bellows Falls.

E 9. *Gold Brand Excelsior Guano;* Barton.

E10. *High Grade Ammoniated Bone Superphosphate;* Hartland.

C 10 *New Englander Corn and Potato Fertilizer;* Montpelier.

K 3. *Prize Brand Grass and Grain;* Manchester.

J 14. *Special Potato and Fruit Grower;* Morrisville.

ESSEX FERTILIZER CO., 39 North Market St., Boston, Mass.

F 8. *A1 Superphosphate;* Johnson.
D 3. *Complete Manure for Corn, Grain and Grass;* Bradford.
D 4. *Complete Manure for Potatoes, Roots and Vegetables;* Derby.
F 7. *Grass and Oats Fertilizer;* Bristol.
D 5. *Market Garden and Potato Manure;* Montpelier.
D 6. *XXX Fish and Potash;* Barre.

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

G 5. *G. Brand;* Ludlow.
K 8. *Grain and Grass Fertilizer;* Bradford.
G 6. *Grass and Oats Fertilizer;* Sheldon.
J 1. *Oneida Special;* Plainfield.
G 2. *Potato Manure;* Fairlee.
G 3. *Special Corn Fertilizer;* Sheldon Springs.
G 4. *Special Potato Fertilizer;* Chester.
D10. *Special Ten Percent Potato Fertilizer;* Chester.
D11. *Success Fertilizer;* Sheldon.

LOWELL (SWIFT'S) FERTILIZER CO., 44 North Market St., Boston, Mass.

J 2. *Animal Brand of all Crops;* Essex.
F 13. *Bone Fertilizer for Corn and Grain;* Groton.
D 8. *Cereal Fertilizer;* Enosburg Falls.
F11. *Empress Brand;* Castleton.
D 7. *Potato Manure;* Brandon.
F12. *Potato Phosphate;* Bennington.
J 12. *Special Potato;* St. Albans.
D 9. *Sterling Phosphate;* Groton.
J 3. *Superior Phosphate;* Essex Junction.

NEW ENGLAND FERTILIZER CO., 42 North Market St., Boston, Mass.

J 4. *Complete Manure;* Saxtons River.
D12. *Corn and Grain Fertilizer;* Sheldon.
F14. *Corn Phosphate;* Sheldon.

F15. *Peerless Fertilizer;* Newport.
D13. *Potato Fertilizer;* Norwich.

PARMENTER AND POLSEY FERTILIZER Co., 40 North Market St. Boston, Mass.

J 11. *Corn and Grain Fertilizer;* Plainfield.
E 4. *Grain Grower;* Springfield.
E 1. *Plymouth Rock Fertilizer;* Springfield.
E 5. *Potato Fertilizer;* Lyndon.
E 3. *Potato Grower;* Plainfield.
E 2. *Star Brand Superphosphate;* Springfield.

ROGERS AND HUBBARD Co., Middletown, Conn.

G 12. *Complete Phosphate;* East Berkshire.
G13. *Grass and Grain Fertilizer;* Bradford.
D14. *New Market Garden Fertilizer;* Barre.
G11. *Oats and Top Dressing;* Barre.
G10. *Potato Phosphate;* Barre.
D15. *Soluble Corn and General Crop;* East Berkshire.
G14. *Soluble Potato Manure;* Lyndon.
J 5. *Soluble Tobacco Manure;* Springfield.

SANDERSON FERTILIZER AND CHEMICAL Co., New Haven, Conn.

D 16. *Atlantic Coast Bone, Fish and Potash;* Middlebury.
J 7. *Corn Superphosphate;* Middlebury.
J 8. *Formula A;* Vergennes.
G 8. *Potato Manure;* Cambridge.
J 9. *Special Ten Percent;* Essex Junction.

Special notice. The following brands licensed for sale in 1909 were not thus licensed in 1910. Coe-Mortimer Co's New Englander Corn Fertilizer, Coe-Mortimer Co.'s New Englander Potato Fertilizer (these two brands have been merged into one, the sale of which is licensed viz.: the New Englander Corn and Potato Fertilizer); Parmenter and Polsey Co.'s Aroostook Special, Maine State and Special Potato Fertilizer.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.						$								$			$
E 16	Grass and Lawn Topdress...	4.20	0.14	0.22	**4.56**	*3.91*	14.77	1.52	4.28	1.08	**6.88**	*6.*	**5.80**	*5.*	5.22	**3.24**	*3.*	2.76
K 2	Grass and Oats Fertilizer..	....	....	....	....	....	....	9.04	2.74	1.70	**13.48**	*12.*	**11.78**	*11.*	11.01	**2.14**	*2.*	1.82
E 14	High Grade Ten Percent...	0.80	1.02	1.17	**2.99**	*2.47*	10.50	3.68	2.10	1.28	**7.06**	*7.*	**5.78**	*6.*	5.50	**10.20**	*10.*	8.67
E 15	N. W. Chal. Crop Grower...	....	0.63	0.83	**1.46**	*1.03*	5.34	6.24	2.20	1.16	**9.60**	*9.*	**8.44**	*8.*	7.84	**2.39**	*2.*	2.03
K 11	XXX Phosphate and Potash....	....	....	....	....	....	....	7.48	2.84	0.86	**11.18**	*11.*	**10.32**	*10.*	9.34	**10.59**	*8.*	9.00
	Bradley Fert. Co. brands																	
K 1	Alkaline Bone and Potash..	....	....	....	....	....	....	8.12	2.72	2.40	**13.24**	*12.*	**10.84**	*11.*	10.45	**2.52**	*2.*	2.14
E 13	Complete Potato and Veg...	1.41	1.05	1.16	**3.62**	*3.29*	12.51	6.48	1.36	1.20	**9.04**	*9.*	**7.84**	*8.*	7.40	**6.90**	*7.*	5.87
A 7	Complete with 10% Potash	1.48	1.37	0.80	**3.65**	*3.29*	12.32	3.36	1.98	0.96	**6.30**	*7.*	**5.34**	*6.*	4.98	**10.09**	*10.*	8.58
A 2	Corn Phosphate	...	1.12	1.18	**2.30**	*2.06*	8.30	6.76	1.76	1.16	**9.68**	*9.*	**8.52**	*8.*	7.95	**1.91**	*1.5*	1.62
E 11	Eclipse Phosphate	...	0.56	0.83	**1.39**	*1.03*	5.11	6.24	2.02	1.36	**9.62**	*9.*	**8.26**	*8.*	7.78	**2.74**	*2.*	2.33

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

			Nitrogen						Phosphoric Acid								Potash		
Station number	Brand	From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																		
	Bradley Fert. Co. brands—Cont.						$								$			$
E 12	Green Mountain Special	0.67	0.84	0.63	**2.14**	*1.65*	7.35	7.64	1.62	1.64	**10.90**	*9.*	**9.26**	*8.*	8.83	**5.10**	*5.*	4.34
A 8	High Grade Potato & Roots	0.40	1.37	0.69	**2.46**	*1.65*	8.42	6.00	2.96	1.56	**10.52**	*9.*	**8.96**	*8.*	8.39	**8.44**	*10.*	7.17
A 3	Niagara Phosphate	...	0.44	0.75	**1.19**	*0.82*	4.41	6.76	2.46	1.56	**10.78**	*8.*	**9.22**	*7.*	8.67	**2.26**	*1.*	1.92
A 4	Potato Fertilizer	...	1.19	1.11	**2.30**	*2.06*	8.25	6.56	2.44	1.20	**10.20**	*9.*	**9.00**	*8.*	8.33	**3.16**	*3.*	2.69
A 6	Potato Manure	1.13	1.24	1.10	**3.47**	*2.47*	11.99	4.44	1.68	1.14	**7.26**	*7.*	**6.12**	*6.*	5.79	**7.88**	*5.*	6.70
A 5	Vermonter	0.22	0.82	1.28	**2.32**	*2.06*	8.44	6.88	2.12	1.16	**10.16**	*9.*	**9.00**	*8.*	8.35	**3.35**	*3.*	2.85
A 1	XL Superphos. of Lime	0.51	1.37	0.98	**2.86**	*2.47*	9.93	8.00	1.98	1.34	**11.32**	*10.*	**9.98**	*9.*	9.32	**2.74**	*2.*	2.33
	Clark's Cove Fert. Co. brands																		
H 7	Bay State Fertilizer G. G.	0.57	0.83	0.81	**2.21**	*2.06*	7.72	7.52	1.68	1.86	**11.06**	*9.*	**9.20**	*8.*	8.85	**1.79**	*1.5*	1.52
H 8	King Philip Alkaline Guano	...	0.76	0.50	**1.26**	*1.03*	4.43	6.20	2.76	1.62	**10.58**	*9.*	**8.96**	*8.*	8.44	**2.32**	*2.*	1.97

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*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Clark's Cove Fert. Co. brands—Cont.						$								$			$
H 6	Potato Fertilizer	0.58	0.86	0.86	**2.30**	*2.06*	8.05	7.04	2.62	1.56	**11.22**	*9.*	**9.66**	*8.*	9.06	**3.33**	*3.*	2.83
	Cleveland Dryer Co. brands																	
B 7	Fertilizer for All Crops...... ...		0.46	0.77	**1.23**	*1.03*	4.55	6.52	3.36	1.54	**11.42**	*9.*	**9.88**	*8.*	9.18	**2.19**	*2.*	1.86
B 6	Potato Phosphate	0.53	0.49	1.03	**2.05**	*2.06*	7.39	7.00	2.70	1.78	**11.48**	*9.*	**9.70**	*8.*	9.17	**3.47**	*3.*	2.95
B 5	Superphosphate	0.39	0.84	1.02	**2.25**	*2.06*	8.02	6.52	2.92	1.42	**10.86**	*9.*	**9.44**	*8.*	8.78	**1.92**	*1.5*	1.63
	Crocker F. & C. Co. brands																	
B 3	Ammo. Corn Phosphate.....	0.24	0.60	1.64	**2.48**	*2.06*	9.25	6.12	2.12	2.44	**10.68**	*9.*	**8.24**	*8.*	8.19	**1.80**	*1.5*	1.53
B 4	New Rival Ammo. Superphos. ...		0.56	0.86	**1.42**	*1.03*	5.23	5.96	2.60	1.44	**10.00**	*9.*	**8.56**	*8.*	8.02	**2.40**	*2.*	2.04
B 2	Potato, Hop and Tobacco...	0.31	0.74	1.29	**2.34**	*2.06*	8.52	7.32	1.78	1.66	**10.76**	*9.*	**9.10**	*8.*	8.67	**3.40**	*3.*	2.89
B 1	Special Potato	1.44	1.09	1.14	**3.67**	*3.29*	12.66	3.00	2.66	1.08	**6.74**	*7.*	**5.66**	*6.*	5.26	**10.04**	*10.*	8.53

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Cumberland Bone Phos. Co. brands						$								$			$
H 4	Guano		0.52	0.73	**1.25**	*1.03*	4.58	7.16	2.88	1.68	**11.72**	*9.*	**10.04**	*8.*	9.41	**2.27**	*2.*	1.93
G 1	Potato Fertilizer		1.02	1.46	**2.48**	*2.06*	9.10	6.16	2.64	1.26	**10.06**	*9.*	**8.80**	*8.*	8.15	**3.36**	*3.*	2.86
H 5	Superphosphate		0.88	1.51	**2.39**	*2.06*	8.86	6.72	2.54	1.58	**10.84**	*9.*	**9.26**	*8.*	8.71	**1.69**	*1.5*	1.44
	Darling Fert. Co. brands																	
H 10	Farm Favorite	0.65	0.54	0.91	**2.10**	*2.06*	7.45	7.24	3.08	1.24	**11.56**	*9.*	**10.32**	*8.*	9.48	**3.50**	*3.*	2.98
J 13	General Fertilizer		0.43	1.13	**1.56**	*1.23*	5.90	5.52	2.53	1.47	**9.52**	7.	**8.05**	*6.*	7.58	**3.33**	*3.*	2.83
	East India Chem. Co. brands																	
B 8	Complete Potato Manure. ..	1.05	1.09	1.46	**3.60**	*3.29*	12.69	4.44	2.02	1.08	**7.54**	7.	**6.46**	*6.*	6.04	**10.20**	*10.*	8.67
E 8	Harvest Home Fertilizer.... ...		0.53	0.79	**1.32**	*1.03*	4.86	6.48	2.28	1.26	**10.02**	*9.*	**8.76**	*8.*	8.15	**2.14**	*2.*	1.82
H 3	Standard UnXlD Fertilizer.....		0.83	1.06	**1.89**	*1.65*	6.90	6.88	1.92	1.70	**10.50**	*9.*	**8.80**	*8.*	8.41	**2.59**	*2.*	2.20

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*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Great Eastern Fert. Co. brands						$								$			$
F 10	Garden Special	1.35	0.65	1.76	**3.76**	*3.29*	13.44	6.80	1.74	2.04	**10.58**	*9.*	**8.54**	*8.*	8.32	**7.39**	*7.*	6.28
E 7	General Fertilizer		0.60	0.65	**1.25**	*0.82*	4.52	6.72	2.24	1.14	**10.10**	*9.*	**8.96**	*8.*	8.29	**3.92**	*4.*	3.33
F 9	Northern Corn Special......	0.42	0.91	1.13	**2.46**	*2.06*	8.77	6.76	2.44	1.50	**10.70**	*9.*	**9.20**	*8.*	8.63	**1.88**	*1.5*	1.60
E 6	Potato Manure	0.21	0.74	1.28	**2.23**	*2.06*	8.16	7.68	1.74	1.48	**10.90**	*9.*	**9.42**	*8.*	8.89	**3.18**	*3.*	2.70
	Pacific Guano Co. brands																	
H 11	Nobsque Guano		0.50	0.73	**1.23**	*1.03*	4.52	6.84	2.40	1.38	**10.62**	*9.*	**9.24**	*8.*	8.63	**2.15**	*2.*	1.83
B 10	Potato Special	0.56	0.56	1.04	**2.16**	*2.06*	7.74	6.36	3.14	1.90	**11.40**	*9.*	**9.50**	*8.*	8.99	**3.38**	*3.*	2.87
B 9	Soluble Pacific Guano......	0.49	0.84	1.13	**2.46**	*2.06*	8.78	7.32	2.08	1.86	**11.26**	*9.*	**9.40**	*8.*	8.99	**1.95**	*1.5*	1.66
	Quinnipiac Co. brands																	
H 12	Climax Phosphate		0.63	0.70	**1.33**	*1.03*	4.82	5.12	2.70	1.28	**9.10**	*9.*	**7.82**	*8.*	7.28	**2.58**	*2.*	2.19

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Quinnipiac Co. brands—Cont.						$								$			$
B 13	Corn Manure		0.63	1.73	**2.36**	*2.06*	8.94	6.08	2.30	2.00	**10.38**	*9.*	**8.38**	*8.*	8.11	**1.70**	*1.5*	1.45
B 12	Market Garden Manure.....	1.48	0.98	1.07	**3.53**	*3.39*	12.16	5.68	2.48	1.28	**9.44**	*9.*	**8.16**	*8.*	7.60	**6.87**	*7.*	5.85
B 11	Potato Phosphate	0.73	0.95	0.60	**2.28**	*2.06*	7.79	6.52	2.40	1.66	**10.58**	*9.*	**8.92**	*8.*	8.45	**3.44**	*3.*	2.92
	Read Fert. Co. brands																	
G 9	Farmers' Friend Superphos .	0.49	0.56	1.11	**2.16**	*2.06*	7.80	6.48	3.10	2.42	**12.00**	*9.*	**9.58**	*8.*	9.28	**3.58**	*3.*	3.04
H 13	High Grade Farmers' Friend.	1.15	1.31	1.08	**3.54**	*3.29*	12.19	3.36	1.89	1.03	**6.28**	*7.*	**5.25**	*6.*	4.94	**10.67**	*10.*	9.07
H 14	Leader Blood and Bone...... ...		0.63	0.77	**1.40**	*0.82*	5.10	6.00	1.90	1.14	**9.04**	*8.*	**7.90**	*7.*	7.38	**2.53**	*1.*	2.15
J 10	Potato Manure	0.63	0.95	1.22	**2.80**	*2.47*	9.94	3.64	2.34	1.38	**7.36**	*7.*	**5.98**	*6.*	5.70	**9.76**	*10.*	8.30
B 14	Practical Potato Special....	0.48	0.77	0.56	**1.81**	*0.82*	6.24	6.84	1.88	1.40	**10.12**	*5.*	**8.72**	*4.*	8.23	**9.21**	*8.*	7.83
F 16	Standard Superphosphate... ...		0.63	0.78	**1.41**	*0.82*	5.14	5.88	2.20	1.20	**9.28**	*9.*	**8.08**	*8.*	7.53	**4.61**	*4.*	3.92

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*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Read Fert. Co. brands—Cont.						$								$			$
K 9	Sure Catch Fertilizer........ ...	....	....	....	....	....	....	7.72	3.52	2.82	**14.06**	*11.*	**11.24**	*10.*	10.90	**2.02**	*2.*	1.72
	H. F. Tucker Co. brands																	
G 7	Imperial for All Crops........ ...		0.74	0.73	**1.47**	*1.03*	5.29	6.16	3.30	1.40	**10.86**	*9.*	**9.46**	*8.*	8.74	**2.24**	*2.*	1.90
B 15	Imperial for Corn............ ...		0.46	0.77	**1.23**	*1.03*	4.55	7.20	1.84	1.70	**10.74**	*9.*	**9.04**	*8.*	8.63	**2.08**	*2.*	1.77
B 16	Imperial for Potatoes......... ...		0.49	0.76	**1.25**	*1.03*	4.61	6.60	2.56	1.50	**10.66**	*9.*	**9.16**	*8.*	8.59	**2.04**	*2.*	1.73
	Williams & Clark Fert. Co. brands.																	
C 1	Amer. Corn Phosphate.....	0.56	0.91	0.88	**2.35**	*2.06*	8.22	7.24	2.60	1.40	**11.24**	*9.*	**9.84**	*8.*	9.16	**2.46**	*1.5*	2.09
C 3	High Grade Spec. Potato, etc. ...		0.91	2.69	**3.60**	*3.29*	13.67	5.24	2.46	2.21	**9.91**	*9.*	**7.70**	*8.*	7.57	**6.72**	*7.*	5.71
C 4	Amer. Potato Manure......	0.67	0.77	0.79	**2.23**	*2.06*	7.76	7.32	2.88	0.98	**11.18**	*9.*	**10.20**	*8.*	9.28	**3.66**	*3.*	3.11
H 15	Potato Phosphate	1.09	0.70	1.14	**2.93**	*2.47*	10.29	5.72	2.29	1.57	**9.58**	*7.*	**8.01**	*6.*	7.61	**5.55**	*5.*	4.71

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Amer. Agl. Chem. Co.																	
	Williams & Clark Fert. Co. brands—Cont.						$								$			$
H 16	Prolific Crop Producer	...	0.65	0.77	**1.42**	*0.82*	5.16	5.92	1.90	1.12	**8.94**	*8.*	**7.82**	*7.*	7.30	**2.37**	*1.*	2.01
C 2	Royal Bone Phosphate	...	0.63	0.72	**1.35**	*1.03*	4.90	6.08	2.69	1.03	**9.80**	*9.*	**8.77**	*8.*	8.03	**2.06**	*2.*	1.75
	Armour Fertilizer Works.																	
H† 1	Complete Manure	1.53	0.57	1.56	**3.66**	*3.29*	12.96	5.24	1.36	0.86	**7.46**	..	**6.60**	*6.*	6.15	†**10.44**	*10.*	9.32
G 16	Corn Special	...	0.11	1.74	**1.85**	*1.65*	7.31	5.44	2.98	2.12	**10.54**	*8.5*	**8.42**	*8.*	8.13	**5.99**	*5.*	5.09
J 6	General Farm	...	0.32	0.44	**0.76**	*0.82*	2.78	2.92	6.06	0.96	**9.94**	*8.5*	**8.98**	*8.*	7.86	**3.20**	*3.*	2.72
G 15	High Grade Potato	...	0.88	0.89	**1.77**	*1.65*	6.38	5.48	2.66	1.46	**9.60**	*8.5*	**8.14**	*8.*	7.64	**9.80**	*10.*	8.33
K 10	Oats and Clover Special	...	....	....	....	....	....	6.32	3.50	1.46	**11.28**	*10.5*	**9.82**	*10.*	9.07	**8.08**	*8.*	6.87
	Bowker Fertilizer Co.																	
A 10	Corn Phosphate	0.29	0.91	0.92	**2.12**	*1.65*	7.52	6.80	2.40	1.00	**10.20**	*9.*	**9.20**	*8.*	8.44	**2.14**	*2.*	1.82

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*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644. †Potash partly as sulphate.

Station number	BRAND	NITROGEN						PHOSPHORIC ACID								POTASH		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Bowker Fertilizer Co.						$								$			$
F 2	Early Potato Manure	0.59	1.02	1.95	**3.56**	*3.29*	12.92	6.92	1.44	2.42	**10.78**	*9.*	**8.36**	*8.*	8.35	**6.89**	*7.*	5.86
F 4	Hill and Drill Phosphate	0.81	0.98	1.00	**2.79**	*2.47*	9.73	6.72	2.52	1.38	**10.62**	*10.*	**9.24**	*9.*	8.62	**2.61**	*2.*	2.22
F 5	Market Garden Fertilizer	0.59	0.74	1.34	**2.67**	*2.47*	9.62	5.24	2.88	1.04	**9.16**	*7.*	**8.12**	*6.*	7.44	**9.81**	*10.*	8.34
F 3	Potash Bone	...	0.53	0.93	**1.46**	*0.83*	5.42	6.48	2.22	2.02	**10.72**	*7.*	**8.70**	*6.*	8.42	**2.20**	*2.*	1.88
A 13	Potash or Staple Phosphate	...	0.74	0.61	**1.35**	*0.82*	4.81	7.20	1.98	0.90	**10.08**	*9.*	**9.18**	*8.*	8.42	**3.38**	*3.*	2.87
H 2	Potato and Vegetable Fert.	0.38	1.44	0.99	**2.81**	*2.47*	9.79	6.52	2.44	1.56	**10.52**	*9.*	**8.96**	*8.*	8.44	**5.10**	*4.*	4.34
A 12	Potato and Vegetable Phos.	0.30	0.91	0.98	**2.19**	*1.64*	7.79	6.56	2.64	1.22	**10.42**	*9.*	**9.20**	*8.*	8.50	**2.34**	*2.*	1.99
F 6	Square Brand Bone & Potash	0.28	0.84	0.85	**1.97**	*1.64*	6.99	6.52	3.04	1.02	**10.58**	*7.*	**9.56**	*6.*	8.70	**2.28**	*2.*	1.94
A 14	Stockbridge Corn and Grain	2.92	....	0.61	**3.53**	*3.29*	11.78	8.24	2.09	0.63	**10.96**	*11.*	**10.33**	*10.*	9.34	**7.35**	*7.*	6.25
A 15	Stockbridge Potato Manure	1.45	0.64	1.35	**3.44**	*3.29*	12.09	5.56	1.40	1.04	**8.00**	*7.*	**6.96**	*6.*	6.54	**10.08**	*10.*	8.57
A 16	Stockbridge Top Dressing	2.25	1.05	1.91	**5.21**	*4.94*	18.20	3.56	1.76	1.10	**6.42**	*6.*	**5.32**	*4.*	5.05	**6.05**	*6.*	5.14

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Bowker Fertilizer Co.						$								$			$
K 6	Superphosphate with Potash	....	....	....	....	....	4.98	9.36	2.32	1.70	**13.38**	*11.*	**11.68**	*10.*	10.96	**2.32**	*2.*	1.97
A 11	Sure Crop Phosphate		0.78	0.62	**1.40**	*0.82*	....	7.20	2.84	1.02	**10.98**	*9.*	**9.96**	*8.*	9.09	**2.18**	*2.*	1.85
A 9	Vt. Grange Chem. D Brand	0.70	0.46	1.02	**2.18**	*2.06*	7.79	7.12	2.68	1.80	**11.68**	*9.*	**9.88**	*8.*	9.34	**3.52**	*3.*	2.99
	J. F. Bromley																	
C 5	Banner Brand	1.55	0.11	2.12	**3.78**	*3.29*	13.79	6.00	2.00	0.74	**8.74**	*8.5*	**8.00**	*8.*	7.30	**9.34**	*9.*	7.94
F 1	Corn and Potato		....	1.35	**1.35**	*1.23*	5.40	8.36	1.48	0.80	**10.64**	*9.*	**9.84**	*8.5*	9.02	**2.90**	*2.5*	2.47
K 7	Grain and Grass		....	....	....	....	....	7.64	2.30	1.48	**11.42**	*10.5*	**9.94**	*10.*	9.31	**2.07**	*2.*	1.76
C 9	Green Mountain Brand		0.18	1.19	**1.37**	*1.23*	5.34	6.24	2.64	0.66	**9.54**	*8.5*	**8.88**	*8.*	7.99	**5.23**	*5.*	4.45
C 8	Potato Special	0.95	0.11	0.99	**2.05**	*1.65*	7.35	6.68	1.58	0.78	**9.04**	*8.5*	**8.26**	*8.*	7.58	**10.35**	*10.*	8.80
C 7	Special Corn Fertilizer	0.25	0.11	0.57	**0.93**	*0.82*	3.43	5.16	2.68	0.98	**8.82**	*8.*	**7.84**	*7.5*	7.17	**3.04**	*3.*	2.58
C 6	Special Potato Fertilizer	0.25	....	0.70	**0.95**	*0.82*	3.60	5.48	2.81	1.18	**9.47**	*8.*	**8.29**	*7.5*	7.65	**3.40**	*3.*	2.89

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Buffalo Fertilizer Co.						$								$			$
C 16	Celery and Potato Special	0.38	0.39	1.16	**1.93**	*1.64*	7.11	5.00	3.14	0.94	**9.08**	*9.*	**8.14**	*8.*	7.39	**10.86**	*10.*	9.23
K† 4	Extra Phosphate and Potash	....	....	....	....	....	....	5.80	4.46	1.38	**11.64**	*11.*	**10.26**	*10.*	9.34	**†8.04**	*8.*	7.08
C 14	Farmers' Choice	....	0.21	1.04	**1.25**	*0.8*	4.83	4.08	4.38	1.42	**9.88**	*9.*	**8.46**	*8.*	7.74	**4.93**	*5.*	4.19
C 12	Fish Guano	....	0.21	0.88	**1.09**	*0.8*	4.19	3.32	5.94	1.36	**10.62**	*10.*	**9.26**	*9.*	8.27	**2.02**	*2.*	1.72
K 5	General Crop	....	....	....	....	....	....	3.72	5.00	1.42	**10.14**	*10.*	**8.72**	*9.*	7.92	**3.34**	*3.*	2.84
C 15	High Grade Manure	....	1.47	2.04	**3.51**	*3.3*	12.86	4.72	2.86	0.62	**8.20**	*8.*	**7.58**	*7.*	6.79	**9.58**	*10.*	8.14
C 13	Ideal Wheat and Corn	1.26	0.14	0.60	**2.00**	*1.6*	6.88	4.76	4.93	1.24	**10.93**	*10.*	**9.69**	*9.*	8.72	**4.90**	*5.*	4.17
	Burlington Rendering Co.																	
D 1	Animal Fertilizer	....	0.14	2.41	**2.55**	*2.*	10.09	3.02	2.78	2.50	**8.30**	*7.*	**5.80**	*4.*	5.93	**4.58**	*4.*	3.89
D 2	Special Potato	....	0.11	2.66	**2.77**	*2.46*	10.99	1.28	2.86	3.90	**8.04**	*8.*	**4.14**	*5.*	5.01	**6.96**	*6.*	5.91

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644. †Potash partly as sulphate.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Coe-Mortimer Co.						$								$			$
C 11	Columbian Corn and Potato. ...		0.21	1.28	**1.49**	*1.23*	5.79	6.04	3.20	1.28	**10.52**	*9.5*	**9.24**	*8.5*	8.50	**3.40**	*2.5*	2.89
E 9	Gold Brand Excel. Guano... ...		1.47	1.03	**2.50**	*2.47*	8.82	3.40	4.66	2.26	**10.32**	*9.*	**8.06**	*8.*	7.69	**6.76**	*6.*	5.75
E 10	H. G. Ammo. Bone Super... ...		0.14	1.79	**1.93**	*1.85*	7.61	5.64	2.72	1.30	**9.66**	*9.*	**8.36**	*8.*	7.78	**3.30**	*3.*	2.81
C 10	New Eng. Corn and Potato.. ...		0.18	1.03	**1.21**	*0.82*	4.70	5.32	2.64	0.48	**8.44**	*8.5*	**7.96**	*7.5*	7.09	**3.08**	*3.*	2.62
K 3	Prize Brand Grass & Grain. ...	....	....	....	....	....	....	3.72	6.06	1.18	**10.96**	*11.*	**9.78**	*10.*	8.67	**2.02**	*2.*	1.72
J 14	Spec. Potato & Fruit Grower ...		0.98	0.60	**1.58**	*1.65*	5.54	5.36	2.60	0.96	**8.92**	*9.*	**7.96**	*8.*	7.28	**11.48**	*10.*	9.76
	Essex Fertilizer Co.																	
F 8	A1 Superphosphate		0.11	1.29	**1.40**	*1.23*	5.51	4.68	2.60	1.32	**8.60**	*8.*	**7.28**	*7.*	6.82	**2.56**	*2.*	2.18
D 3	Complete for Corn & Grain. ...		0.49	2.78	**3.27**	*3.28*	12.69	4.28	1.91	1.16	**7.35**	*7.*	**6.19**	*6.*	5.84	**10.70**	*10.*	9.10
D 4	Complete for Potatoes....... ...		0.70	2.59	**3.29**	*3.28*	12.60	4.66	2.35	0.89	**7.90**	*7.*	**7.01**	*6.*	6.43	**10.10**	*10.*	8.59
F 7	Grass and Grain		....	1.14	**1.14**	*0.82*	4.56	6.64	2.02	1.44	**10.10**	*9.*	**8.66**	*8.*	8.18	**3.94**	*4.*	3.35

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*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Essex Fertilizer Co.						$								$			$
D 5	Market Garden and Potato.		0.56	1.86	**2.42**	*2.*	9.23	6.32	1.79	1.44	**9.55**	*9.*	**8.11**	*8.*	7.70	**5.47**	*5.*	4.65
D 6	XXX Fish and Potash.		0.14	2.18	**2.32**	*2.*	9.17	5.14	3.29	0.79	**9.22**	*9.*	**8.43**	*8.*	7.58	**3.20**	*3.*	2.72
	Lister's Ag'l Chem. Works																	
G 5	G Brand		0.21	1.05	**1.26**	*0.82*	4.87	5.72	3.02	1.84	**10.58**	*9.*	**8.74**	*8.*	8.30	**4.68**	*4.*	3.99
K 8	Grain and Grass Fertilizer.		....	....	....	....	....	7.64	2.60	0.56	**10.80**	*11.*	**10.24**	*10.*	9.18	**2.21**	*2.*	1.88
G 6	Grass and Oats Fertilizer.		0.28	1.02	**1.30**	*0.82*	4.98	5.36	3.02	2.04	**10.42**	*9.*	**8.38**	*8.*	8.05	**4.33**	*4.*	3.68
J 1	Oneida Special		0.21	1.00	**1.21**	*0.82*	4.67	4.36	3.30	1.22	**8.88**	*8.*	**7.66**	*7.*	7.05	**1.57**	*1.*	1.33
G 2	Potato Manure		1.82	1.82	**3.64**	*3.29*	13.10	6.04	2.24	1.88	**10.16**	*9.*	**8.28**	*8.*	7.98	**6.43**	*7.*	5.47
G 3	Special Corn Fertilizer.		0.25	1.26	**1.51**	*1.23*	5.84	6.16	2.24	2.20	**10.60**	*9.*	**8.40**	*8.*	8.21	**3.48**	*3.*	2.96
G 4	Special Potato Fertilizer.		0.21	2.02	**2.23**	*1.65*	8.75	5.16	2.94	1.92	**10.02**	*9.*	**8.10**	*8.*	7.76	**3.51**	*3.*	2.98
D 10	Special Ten Percent Potato.		0.53	1.47	**2.00**	*1.65*	7.58	5.56	2.36	2.29	**10.21**	*9.*	**7.92**	*8.*	7.81	**11.02**	*10.*	9.37

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Lister's Ag'l Chem. Works						$								$			$
D 11	Success Fertilizer	0.21	1.16	**1.87**	*1.23*	5.31	6.96	2.44	1.63	**11.08**	*10.*	**9.40**	*9.*	8.86	**2.55**	*2.*	2.17
	Lowell (Swift) Fert. Co.																	
J 2	Animal Brand	0.60	1.96	**2.56**	*2.46*	9.76	5.36	2.78	0.76	**8.90**	*10.*	**8.14**	*8.*	7.34	**4.14**	*4.*	3.52
F 13	Bone Fert. for Corn & Grain ...	0.39	1.56	**1.95**	*1.64*	7.49	6.72	2.22	1.18	**10.12**	*9.*	**8.94**	*8.*	8.30	**3.18**	*3.*	2.66
D 8	Cereal Fertilizer	....	0.90	**0.90**	*0.82*	3.60	4.68	2.58	1.02	**8.28**	*8.*	**7.26**	*7.*	6.68	**1.30**	*1.*	1.11
F 11	Empress Brand	....	1.37	**1.37**	*1.25*	5.48	4.44	3.08	1.30	**8.82**	*8.*	**7.52**	*7.*	6.99	**2.47**	*2.*	2.10
D 7	Potato Manure	0.49	1.32	**1.81**	*1.64*	6.85	4.76	2.10	0.54	**7.40**	*8.*	**6.86**	*7.*	6.17	**4.06**	*4.*	3.45
F 12	Potato Phosphate	0.25	2.24	**2.49**	*2.46*	9.76	5.84	2.64	1.08	**9.56**	*9.*	**8.48**	*8.*	7.80	**6.53**	*6.*	5.55
J 12	Special Potato............... ...	0.14	2.50	**2.64**	*2.46*	10.45	3.32	3.32	2.12	**8.76**	*7.*	**6.64**	*6.*	6.49	**10.44**	*10.*	8.88
D 9	Sterling Phosphate	....	1.12	**1.12**	*0.82*	4.48	6.60	2.54	1.23	**10.37**	*9.*	**9.14**	*8.*	8.46	**4.10**	*4.*	3.49
J 3	Superior Phosphate	0.77	3.26	**4.08**	*3.69*	15.50	1.24	6.06	1.14	**8.44**	*8.*	**7.30**	*7.*	6.43	**10.04**	*10.*	8.53

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

Station number	Brand	Nitrogen						Phosphoric Acid								Potash		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	New England Fertilizer Co.						$								$			$
J 4	Complete Manure		0.21	3.65	**3.86**	*3.28*	15.27	3.72	2.80	1.26	**7.78**	*7.*	**6.52**	*6.*	6.09	**9.83**	*10.*	8.36
D 12	Corn and Grain Fertilizer.. ...		0.14	1.44	**1.58**	*1.23*	6.21	4.74	2.92	1.09	**8.75**	*8.*	**7.66**	*7.*	7.05	**2.20**	*2.*	1.87
F 14	Corn Phosphate		0.42	1.46	**1.88**	*1.64*	7.18	6.68	1.94	1.36	**9.98**	*9.*	**8.62**	*8.*	8.10	**3.40**	*3.*	2.89
F 15	Peerless Fertilizer		....	1.00	**1.00**	*0.82*	4.00	5.08	2.26	1.22	**8.56**	*8.*	**7.34**	*7.*	6.87	**1.22**	*1.*	1.04
D 13	Potato Fertilizer		0.42	1.46	**1.88**	*1.64*	7.18	5.08	2.38	0.37	**7.83**	*8.*	**7.46**	*7.*	6.62	**3.83**	*4.*	3.25
	Parmenter & Polsey Fert. Co.																	
J 11	Corn and Grain Fertilizer.. ...		0.11	0.98	**1.09**	*0.82*	4.27	6.24	2.16	1.98	**10.38**	*9.*	**8.40**	*8.*	8.14	**3.96**	*4.*	3.37
E 4	Grain Grower		....	1.42	**1.42**	*1.23*	5.68	5.20	2.30	1.04	**8.54**	*8.*	**7.50**	*7.*	6.94	**2.36**	*2.*	2.01
E 1	Plymouth Rock Fertilizer...	0.21	0.11	2.12	**2.44**	*2.46*	9.50	5.16	2.64	1.96	**9.76**	*10.*	**7.80**	*8.*	7.53	**4.26**	*4.*	3.62
E 5	Potato Fertilizer		0.11	1.80	**1.91**	*1.64*	7.55	3.84	2.80	1.02	**7.66**	*7.*	**6.64**	*6.*	6.11	**6.14**	*6.*	5.22

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

ANALYSES OF LICENSED FERTILIZERS

Station number	Brand	Nitrogen: From nitrates	Nitrogen: From ammonia salts	Nitrogen: From organic matter	Nitrogen: Total found	Nitrogen: Total guaranteed	Nitrogen: Valuation of nitrogen‡	Phosphoric Acid: Soluble	Phosphoric Acid: Reverted	Phosphoric Acid: Insoluble	Phosphoric Acid: Total found	Phosphoric Acid: Total guaranteed	Phosphoric Acid: Available found	Phosphoric Acid: Available guaranteed	Phosphoric Acid: Valuation of phosphoric acid‡	Potash: Found	Potash: Guaranteed	Potash: Valuation of potash‡
	Parmenter & Polsey Fert. Co.						$								$			$
E 3	Potato Grower with 10% Pot.	...	0.14	2.67	**2.81**	*2.46*	11.13	3.32	3.00	1.56	**7.88**	*7.*	**6.32**	*6.*	6.01	**9.88**	*10.*	8.40
E 2	Star Brand Superphosphate.	...	0.49	1.58	**2.07**	*1.64*	7.89	5.20	2.40	0.54	**8.14**	*8.*	**7.60**	*7.*	6.82	**4.04**	*4.*	3.43
	Rogers & Hubbard Co.																	
G 12	Complete Phosphate	0.46	0.14	1.03	**1.63**	*1.5*	6.04	4.68	3.82	1.80	**10.30**	*8.*	**8.50**	*7.*	7.99	**5.96**	*5.*	5.07
G 13	Grass and Grain Fertilizer..	...	0.18	2.41	**2.59**	*2.2*	10.22	0.40	9.84	7.68	**17.92**	*16.*	**10.24**	*6.6*	11.30	**12.86**	*10.*	10.93
D 14	New Market Garden Fert...	0.84	0.14	1.07	**2.05**	*2.*	7.42	3.60	3.85	1.39	**8.84**	*7.*	**7.45**	*6.*	6.88	**10.67**	*10.*	9.07
G 11	Oats and Top Dressing.....	7.58	....	0.65	**8.23**	*8.5*	26.86	0.32	6.10	4.14	**10.56**	*8.*	**6.42**	*3.9*	6.83	**8.79**	*8.*	7.47
G 10	Potato Phosphate	0.95	....	1.22	**2.17**	*2.*	7.93	6.52	3.28	3.12	**12.92**	*10.*	**9.80**	*9.*	9.74	**5.48**	*5.*	4.66
D 15	Soluble Corn & Gen. Crops..	1.37	0.14	1.37	**2.88**	*2.5*	10.31	2.04	5.75	2.46	**10.25**	*8.*	**7.79**	*5.5*	7.43	**8.72**	*8.*	7.41
G*14	Soluble Potato Manure.....	2.11	0.28	2.91	**5.30**	*5.*	19.29	0.56	6.74	4.46	**11.76**	*10.*	**7.30**	*7.*	7.67	***5.84**	*5.*	5.64
J* 5	Soluble Tobacco Manure....	1.96	0.28	2.63	**5.07**	*5.*	18.49	0.40	7.22	4.06	**11.68**	*10.*	**7.62**	*7.*	7.76	***10.95**	*10.*	10.76

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 614.

Station number	BRAND	NITROGEN						PHOSPHORIC ACID								POTASH		
		From nitrates	From ammonia salts	From organic matter	Total found	Total guaranteed	Valuation of nitrogen‡	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Valuation of phosphoric acid‡	Found	Guaranteed	Valuation of potash‡
	Sanderson Fert. & Chem. Co.						$								$			$
D*16	Atl. Coast Bone, Fish & Pot. ...		0.56	2.07	**2.63**	*1.67*	10.07	1.02	4.26	1.92	**7.20**	*6.*	**5.28**	*4.*	5.10	***4.58**	*4.*	4.37
J 7	Corn Superphosphate		0.35	2.06	**2.41**	*1.67*	9.34	1.44	5.86	2.32	**9.62**	*9.*	**7.30**	*7.*	6.92	**2.89**	*2.*	2.46
J 8	Formula A	1.08	0.74	1.74	**3.56**	*3.33*	12.78	4.04	3.50	1.90	**9.44**	*9.*	**7.54**	*6.*	7.20	**7.25**	*6.*	6.16
G 8	Potato Manure		0.28	1.56	**1.84**	*1.62*	7.14	1.96	4.50	1.70	**8.16**	*8.*	**6.46**	*5.*	6.04	**6.69**	*6.*	5.69
J 9	Special Ten Percent......... ...		0.24	2.43	**2.67**	*2.47*	10.49	2.64	3.20	1.40	**7.22**	*8.*	**5.84**	*5.*	5.50	**10.54**	*10.*	8.96

*Potash in brands thus marked is largely if not entirely as sulphate. ‡See definition, page 644.

VI. ANALYSES OF FERTILIZERS FOR FIVE YEARS, 1906-1910

The buyer of mixed goods usually makes his choice before the analyses are published. The Station usually prints the analyses of about 60 brands early in April,[1] and puts out its final bulletin in early June. These dates are far in advance of the issuance of similar figures by other northern stations, yet the information they convey often reaches the buyer too late to be of service; and if station analyses are consulted at all, those of former years are used. These may or may not be safe guides. If, however, reference to analyses for successive years show essential uniformity of composition in the past *and an unchanged guaranty,* the buyer is safe in assuming that the former figures will be applicable. If the guaranty statement has been changed, and if former statements have been lived up to in the past years, the presumption is in favor of similar keeping of promises for the present year.

In order to facilitate such reference and to indicate something of the evenness or variation in composition from year to year of the several brands, tables are given herewith showing the nitrogen, available phosphoric acid and potash percentages for the past five years of the 152 licensed brands. The guaranties printed in the tables are those for 1910 as well as for 1906-1909 with a few exceptions, which are foot-noted. The * indicates that sulphate of potash was used as a source of potash, the †, that 0.20 percent or more of nitrogen was present either as nitrate of soda or as sulphate of ammonia or both.

These tables, containing the essentials of five years' inspection, ought to prove helpful in choosing fertilizers, particularly when they are bought early in the season.

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[1] Earlier bulletin omitted in 1910.

ANALYSES OF LICENSED FERTILIZERS—1906-1910

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar
American Agricultural Chem. Co.'s	Grass and Lawn Top Dres.	†4.98	†3.82	†5.40	†4.23	†4.56	*3.91*	6.18	5.50	6.90	5.94	5.80	*5.*	3.12	2.85	*4.49	3.14	3.24	*2.*
	Grass and Oats Fertilizer..	......	......	......	......	......	......	......	......	......	12.13	11.78	*11.*	......	......	......	1.95	2.14	*2.*
	High Grade Ten Percent...	†2.81	†2.74	†2.37	†3.30	†2.99	*2.4*	6.14	6.32	6.00	6.84	5.78	*6.*	10.80	10.75	9.88	10.09	10.20	*10.*
	No. West Chal. Crop. Grow.	......	......	......	1.18	†1.46	*1.03*	......	......	......	9.99	8.44	*8.*	......	......	......	2.36	2.39	*2.*
	XXX Phosphate & Potash	......	......	......	......	......	......	......	......	......	.....	10.32	*8.*	......	......	......	......	10.59	*8.*
	Bradley's Alkaline Bone ...	......	......	......	......	......	......	11.26	11.30	10.32	11.57	10.84	*.11*	2.24	2.36	1.91	2.20	2.52	*2.*
	Bradley's Comp. Pot. Veg..	†3.33	†4.00	†3.49	†3.30	†3.62	*3.3*	8.92	8.20	8.68	7.64	7.84	*8.*	*7.58	7.88	6.73	6.90	6.90	*7.*
	Bradley's Comp. 10 Perc't.	†3.40	†3.58	†3.47	†3.26	†3.65	*3.3*	6.66	6.66	6.78	7.50	5.34	*6.*	10.64	11.24	10.25	9.99	10.09	*10.*
	Bradley's Corn Phosphate	†2.21	†2.14	†2.17	†2.60	†2.30	*2.06*	8.68	8.52	8.36	9.39	8.52	*8.*	2.00	1.84	1.90	2.17	1.91	*1.5*
	Bradley's Eclipse Phos....	1.23	1.33	†0.90	1.31	†1.39	*1.03*	8.58	7.99	9.30	9.58	8.26	*8.*	2.32	2.04	2.12	2.48	2.74	*2.*
	Bradley's Gn. Mt. Special	......	......	......	......	†2.14	*1.65*	......	......	......	......	9.26	*8.*	......	......	.....	......	5.10	*5.*
	Bradley's H.G. Pot. & Root	......	.....	......	.....	†2.46	*1.65*	......	......	......	......	8.96	*8.*	......	......	......	......	8.44	*10.*
	Bradley's Niagara Phos.....	1.40	1.23	1.12	1.12	†1.19	*0.82*	7.50	7.66	7.98	8.01	9.22	*7.*	1.60	1.31	1.45	1.68	2.26	*1.*
	Bradleys' Potato Fertilizer	†2.24	†2.10	†1.98	†2.17	†2.30	*2.06*	8.42	8.14	8.30	9.42	9.00	*8.*	3.48	3.36	3.36	2.97	3.16	*3.*
	Bradley's Potato Manure ..	†2.74	†2.63	†2.83	†2.91	†3.47	*2.47*	6.74	7.94	6.88	6.08	6.12	*6.*	5.44	5.40	6.78	4.98	7.88	*5.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

ANALYSES OF LICENSED FERTILIZERS—1906-1910

	BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
		1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar
American Agricultural Chemical Co.'s	Bradley's Vermonter........	†2.17	†2.32	†2.21	†2.42	†2.32	*2.06*	8.20	8.38	8.18	8.34	9.00	*8.*	3.20	3.35	3.11	3.09	3.35	*3.*
	Bradley's XL Superphos ...	†2.53	†2.70	†2.95	†2.46	†2.86	*2.5*	9.28	9.00	9.08	9.24	9.98	*9.*	2.44	2.33	2.71	2.28	2.74	*2.*
	Clark's Cove Bay State G.G.	†2.17	2.53	†2.14	2.32	†2.21	*2.06*	8.42	9.23	8.38	7.98	9.20	*8.*	2.08	1.98	1.65	1.88	1.79	*1.5*
	Clark's Cove King Philip...	1.33	1.33	1.26	1.26	†1.26	*1.03*	8.94	8.06	8.38	8.34	8.96	*8.*	2.47	2.16	2.06	2.22	2.32	*2.*
	Clark's Cove Potato Fert...	†2.42	†2.39	†2.10	2.39	†2.30	*2.06*	8.84	8.78	8.56	8.10	9.66	*8.*	3.54	3.18	3.50	3.27	3.33	*3.*
	Cleveland Fertilizer..........	1.33	1.23	1.37	1.14	†1.23	*1.03*	8.44	8.38	8.78	9.30	9.88	*8.*	2.36	2.03	2.20	2.24	2.19	*2.*
	Cleveland Potato Phos......	†2.14	†2.10	†2.14	†2.24	†2.05	*2.06*	8.66	8.18	8.26	9.16	9.70	*8.*	3.12	3.85	3.21	3.47	3.47	*3.*
	Cleveland Superphosphate.	†2.14	†2.10	†2.17	†2.24	†2.25	*2.06*	9.02	8.06	8.08	8.66	9.44	*8.*	1.99	1.80	1.92	2.12	1.92	*1.5*
	Crocker's Am. Corn Phos...	†2.21	†2.07	†2.01	†2.35	†2.48	*2.06*	8.66	8.02	8.14	9.10	8.24	*8.*	2.01	1.92	2.25	1.90	1.80	*1.5*
	Crocker's N. Rival Ammo..	1.37	1.16	1.16	†1.16	†1.42	*1.03*	8.54	8.04	8.82	9.34	8.56	*8.*	2.44	1.95	2.05	2.21	2.40	*2.*
	Crocker's Pot., Hop & Tob.	†2.12	†2.10	†2.05	†2.28	†2.34	*2.06*	8.54	7.87	7.68	9.09	9.10	*8.*	3.12	3.78	3.22	3.19	3.40	*3.*
	Crocker's Special Potato....	†3.33	†3.30	†3.33	†3.75	†3.67	*3.3*	6.90	7.32	6.08	7.58	5.66	*6.*	10.45	9.84	10.44	9.84	10.04	*10.*
	Cumberland Guano..........	1.33	....	....	†1.37	†1.25	*1.03*	8.72	....	....	8.70	10.04	*8.*	2.28	....	....	1.93	2.27	*2.*
	Cumberland Potato Fert....	†2.24	†2.17	†1.95	†2.24	†2.48	*2.06*	8.72	7.74	8.66	9.24	8.80	*8.*	3.49	3.10	3.78	3.36	3.36	*3.*
	Cumberland Superphos.....	†2.10	†2.24	†2.14	†2.32	†2.39	*2.06*	8.36	8.00	7.98	8.68	9.26	*8.*	2.03	1.87	1.82	2.32	1.69	*1.5*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

		1906	1907	1908	1909	1910													
American Agricultural Chemical Co.'s	Darling's Farm Favorite....	†2.12	†2.21	†2.05	†2.24	†2.10	*2.06*	8.88	8.12	7.96	8.66	10.32	8.	3.38	3.32	3.01	3.17	3.50	*3.*
	Darling's General Fert......	......	......	......	†1.68	†1.56	*0.82*	....	....	....	7.58	8.05	*8.*	....	....	....	4.18	3.33	*4.*
	E. Ind. Complete Potato...	†3.47	†3.37	†3.44	†3.40	†3.60	*3.3*	6.68	7.34	6.36	6.86	6.46	*6.*	9.12	10.48	9.87	10.18	10.20	*10.*
	E. Ind. Harvest Home......	1.30	1.30	1.12	1.26	†1.32	*1.03*	9.32	8.04	8.08	9.28	8.76	*8.*	2.41	2.00	2.00	2.24	2.14	*2.*
	E. Ind. Standard UnXlD ..	†2.39	†1.82	†1.51	1.75	†1.89	*1.65*	8.14	9.04	8.04	9.60	8.80	*8.*	2.68	2.04	2.24	2.35	2.59	2.
	Great East. Garden Special	†3.65	†3.30	†3.65	†3.56	†3.76	*3.3*	7.79	8.00	8.18	7.12	8.54	*8.*	7.72	7.10	7.26	7.63	7.39	7.
	Great East. General Fert...	1.09	1.09	1.44	1.18	†1.25	*0.82*	8.06	8.08	7.70	7.99	8.96	*8.*	4.70	4.03	5.09	4.05	3.92	*4.*
	Great East. No. Corn Spec.	†2.14	†2.60	†2.21	†2.28	†2.46	*2.06*	8.42	8.60	8.40	8.47	9.20	*8.*	2.23	1.72	1.89	1.75	1.88	*1.5*
	Great East. Potato Manure	†2.14	†2.24	†2.17	†2.17	†2.23	*2.06*	8.78	8.18	8.20	8.61	9.42	*8.*	3.32	3.44	3.20	3.04	3.18	*3.*
	Pac. Gu. Co.'s Nobsque Gu.	1.40	1.30	1.37	1.11	†1.23	*1.03*	8.32	8.15	8.74	9.56	9.24	*8.*	2.32	2.02	2.02	2.02	2.15	*2.*
	Pac. Gu. Co 's Potato Spec.	†2.24	†2.39	†2.07	†2.24	†2.16	*2.06*	9.00	8.08	8.28	8.14	9.50	*8.*	3.40	3.02	3.22	3.34	3.38	*3.*
	Pac. Gu. Co.'s Sol. Pac. Gu.	†2.21	†2.56	†2.14	†2.10	†2.46	*2.06*	8.24	8.02	8.70	8.00	9.40	*8.*	2.14	1.62	1.98	1.77	1.95	*1.5*
	Quinnipiac Climax Phos....	1.40	1.26	1.37	1.35	†1.33	*1.03*	8.26	7.84	8.84	8.38	7.82	*8.*	2.26	1.94	1.99	2.36	2.58	*2.*
	Quinnipiac Corn Manure...	†2.28	†2.24	†2.05	†2.17	†2.36	*2.06*	8.84	8.16	8.18	9.03	8.38	*8.*	2.19	1.80	2.08	2.18	1.70	*1.5*
	Quinnipiac Market Garden	†3.58	†4.07	†3.40	†3.39	†3.53	*3.3*	7.92	7.99	8.03	8.26	8.16	*8.*	8.18	7.84	6.96	7.72	6.87	7.

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

ANALYSES OF LICENSED FERTILIZERS—1906-1910

	Brand	Nitrogen 1906	Nitrogen 1907	Nitrogen 1908	Nitrogen 1909	Nitrogen 1910	Nitrogen Guar	Available Phospho'c Acid 1906	Available Phospho'c Acid 1907	Available Phospho'c Acid 1908	Available Phospho'c Acid 1909	Available Phospho'c Acid 1910	Available Phospho'c Acid Guar	Potash 1906	Potash 1907	Potash 1908	Potash 1909	Potash 1910	Potash Guar
Am. Agricultural Chemical Co.'s	Quinnipiac Potato Phos.....	†2.21	†2.21	†2.07	†2.24	†2.28	*2.06*	8.86	8.30	8.50	9.09	8.92	*8.*	3.51	3.12	3.28	3.08	3.44	*3.*
	Read's Farmers' Friend.....	†2.17	†2.24	†1.81	†2.28	†2.16	*2.06*	8.96	8.26	8.30	8.78	9.58	*8.*	3.40	3.30	3.62	3.18	3.58	*3.*
	Read's H. G. F.'s Friend...	†3.68	†3.72	†3.12	†3.32	†3.54	*3.3*	6.94	6.56	6.30	6.85	5.25	*6.*	11.42	11.27	10.47	10.06	10.67	*10.*
	Read's Leader Bl. and Bone	1.26	1.16	1.19	†1.12	†1.40	*0.82*	8.12	7.02	8.28	7.38	7.90	*7.*	1.34	1.39	1.32	1.02	2.53	*1.*
	Read's Potato Manure	....	....	....	....	†2.80	*2.47*	....	....	....	......	5.98	*6.*	....	....	....	....	9.76	*10.*
	Read's Prac. Potato Spec'l	1.16	1.26	1.51	1.04	†1.81	*0.82*	7.68	6.99	7.24	7.44	8.72	*4.*	8.64	8.08	10.03	8.08	9.21	*8.*
	Read'sStandard Superphos.	1.19	1.09	1.47	1.16	†1.41	*0.82*	8.44	8.08	7.67	8.20	8.08	*8.*	4.06	4.09	5.07	4.09	4.61	*4.*
	Read's Sure Catch Fert......	... ..	......	......	......	......	....	10.74	10.88	10.06	11.99	11.24	*10.*	2.18	2.22	1.57	2.10	2.02	*2.*
	Tucker's Imperial all Crops	1.33	1.33	1.07	1.30	†1.47	*1.03*	8.32	8.50	9.66	9.19	9.46	*8.*	2.52	2.30	2.22	2.59	2.24	*2.*
	Tucker's Imperial Corn......	1.33	1.26	0.88	1.33	†1.23	*1.03*	8.28	8.16	9.56	8.64	9.04	*8.*	2.57	2.14	2.17	2.04	2.08	*2.*
	Tucker's Imperial Potato...	1.44	1.23	1.12	1.47	†1.25	*1.03*	8.34	8.02	9.70	8.54	9.16	*8.*	2.68	2.09	2.31	2.30	2.04	*2.*
	W. & Cl. Am. Corn Phos...	†2.17	†2.60	†1.96	†2.14	†2.35	*2.06*	8.58	8.56	8.48	8.85	9.84	*8.*	1.73	2.04	1.79	2.09	2.46	*1.5*
	W. & Cl. Am. H. G. Sp. Pot	†3.58	†3.40	†3.44	†3.35	†3.60	*3.3*	8.11	8.28	8.01	8.12	7.70	*8.*	7.18	7.03	7.26	6.77	6.72	*7.*
	W. & Cl. Am. Potato Man.	†2.14	†2.32	†2.10	†2.28	†2.23	*2.06*	9.18	8.08	8.16	9.16	10.20	*8.*	3.40	3.79	3.15	3.38	3.66	*3.*
	W. & Cl. Potato Phos.	†2.53	†2.95	†2.74	2.79	†2.93	*2.5*	6.18	7.40	7.28	6.37	8.01	*6.*	5.40	6.86	5.60	4.84	5.55	*5.*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

W. & Cl. Prolific Crop Pro.	1.26	1.12	1.37	1.19	†1.42	*0.82*	6.12	8.20	8.14	7.50	7.82	*7.*	1.42	2.00	1.25	1.67	2.37	*1.*
W. & Cl. Royal Bone Phos.	1.33	1.26	1.33	1.26	†1.35	*1.03*	8.90	8.42	8.80	9.09	8.77	*8.*	2.25	2.00	1.95	2.03	2.06	*2.*
Armour's Complete Man....	......	......	......	†3.21	†3.66	*3.3*	......	......	......	6.52	6.60	*6.*	......	......	......	10.14	*10.44	*10.*
Armour's Corn Special......	......	......	......	1.28	1.85	*1.65*	......	......	......	8.74	8.42	*8.*	......	......	......	5.16	5.99	5.
Armour's General Farm.....	......	......	......	......	†0.76	*0.82*	......	......	......	......	8.98	*8.*	......	......	......	......	3.20	*3.*
Armour's High Gd. Potato.	......	......	......	1.86	†1.77	*1.65*	......	......	......	9.84	8.14	*8.*	......	......	......	10.35	9.80	*10.*
Armour's Oats and Clover..	......	......	......	......	......	......	......	......	......	11.80	9.82	*10.*	......	......	......	8.88	8.08	*8.*
Bowker's Corn Phosphate..	†2.17	†2.00	†1.61	†1.79	†2.12	*1.65*	8.42	8.60	8.54	8.10	9.20	*8.*	2.58	2.32	2.15	2.29	2.14	*2.*
Bowker's Early Potato	†3.72	†3.51	†3.58	......	†3.56	*3.29*	7.47	5.68	8.28	......	8.36	*8.*	7.70	7.42	6.70	6.89	6.89	*7.*
Bowker's Hill and Drill....	†2.77	†2.60	†2.86	†2.74	†2.79	*2.47*	9.31	9.26	9.44	9.90	9.24	*9.*	2.56	2.17	2.68	2.04	2.61	*2.*
Bowker's Market Garden...	†3.02	†2.60	†2.77	†2.49	†2.67	*2.47*	6.12	6.48	6.66	5.74	8.12	*6.*	10.79	10.04	9.85	11.19	9.81	*10.*
Bowker's Potash Bone......	1.40	1.12	1.12	1.14	†1.46	*0.82*	8.76	8.10	8.76	9.08	8.70	*6*	2.12	2.12	1.93	2.26	2.20	*2.*
Bowker's Potash or Staple.	1.23	1.19	†1.30	1.25	†1.35	*0.83*	8.58	7.62	8.98	9.20	9.18	*8.*	3.54	3.24	3.58	4.80	3.38	*3.*
Bowker's Pot. and Veg. F.	†2.56	†2.81	†2.32	2.67	†2.81	*2.47*	9.06	9.44	8.42	9.22	8.96	*8.*	4.40	4.72	4.57	3.84	5.10	*4.*
Bowker's Pot. and Veg. P.	†2.17	†1.89	†1.65	†1.79	†2.19	*1.65*	(a) 8.31	8.82	8.70	8.03	9.20	*8.*	2.48	2.31	2.19	2.24	2.34	*2.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

(a) Available phosphoric acid guaranty, 9 percent.

ANALYSES OF LICENSED FERTILIZERS—1906—1910

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar
Bowker's Square Brand....	†2.14	†1.96	†2.09	†1.98	†1.97	*1.65*	8.56	6.72	8.22	7.85	9.56	*6.*	2.55	2.64	2.33	1.96	2.28	*2.*
Bowker's Stkbdg. Corn M.	†3.79	†3.51	†3.55	†3.68	†3.53	*3.29*	9.26	9.02	8.28	8.75	10.33	*10.*	7.58	7.60	7.01	7.04	7.85	*7.*
Bowker's Stkbdg. Pot. M.	†3.54	†3.33	†3.24	†3.40	†3.44	*3.29*	5.98	6.60	6.14	6.90	6.96	*6.*	9.94	10.10	*10.27	9.98	10.08	*10.*
Bowker's Stkbdg. Top Dr.	....	†6.03	†4.91	†4.77	†5.21	*4.93*	....	6.06	4.44	7.77	5.32	*4.*	....	6.51	7.85	6.60	6.05	*6.*
Bowker's Super with P't'sh	......	......	......	....	.....	......	......	11.40	9.93	11.34	11.68	*10.*	.... .	2.52	1.50	1.80	2.32	*2.*
Bowker's Sure Crop Phos..	1.54	1.09	1.16	1.08	†1.40	*0.82*	(a)7.72	8.23	9.06	8.44	9.96	*8.*	2.50	1.95	2.02	2.37	2.18	*2.*
Bowker's Vt. Grange Ch..	†2.17	......	†2.17	†2.32	†2.18	*2.06*	8.84	......	8.02	8.30	9.68	*8.*	3.02	......	3.05	3.24	3.52	*3.*
Bromley's Banner Brand...	......	......	......	......	†3.78	*3.29*	.....	......	......	......	8.00	*8.*	......	......	.....	......	9.34	*9.*
Bromley's Corn and Potato	......	......	......	.....	1.35	*1.23*	......	......	......	......	9.84	*8.5*	......	......	......	......	2.90	*2.5*
Bromley's Grain & Grass..	......	.....	......	......	......	......	......	......	......	......	9.94	*10.*	......	......	......	......	2.07	*2.*
Bromley's Gr. Mt. Brand..	......	......	......	......	†1.37	*1.23*	......	......	......	......	8.88	*8.*	......	......	......	......	5.23	*5.*
Bromley's Potato Special ..	......	......	......	......	†2.05	*1.65*	......	......	......	......	8.26	*8.*	......	......	......	......	10.35	*10.*
Bromleys's Spec. Corn Fert	......	......	......	......	†0.93	*0.82*	......	......	......	......	7.84	*7.5*	......	... ..	......	......	3.04	*3.*
Bromley's Spec. Pot. Fert.	......	......	......	......	†0.95	*0.82*	......	......	.....	......	8.29	*7.5*	......	......	......	......	3.40	*3.*
Buff. F. Co. Celery & Pot..	......	......	†1.68	†1.65	†1.93	*1.64*	......	......	7.71	8.08	8.14	*8.*	.....	.....	10.45	10.64	10.86	*10.*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

Buff. F. Co. Ex. Phos. & Pot.	......	......	......	......	......	......	......	......	......	10.78	10.26	*10.*	......	......	......	6.95	8.04	*8.*
Buff. F. Co. Farm. Choice..	0.98	0.98	†1.09	1.19	†1.25	*0.82*	8.13	6.28	8.48	9.88	8.46	*8.*	*4.40	4.14	5.02	4.72	4.93	*5.*
Buff. F. Co. Fish Guano....	1.05	1.43	†1.26	1.12	†1.09	*0.82*	9.14	6.76	9.28	9.69	9.26	*9.*	*2.54	3.14	3.25	1.89	2.02	*2.*
Buff. F. Co. General Crop..	......	......	......	......	......	......	8.90	9.20	10.77	9.62	8 72	*9.*	*2.35	3.65	5.15	3.02	3.34	*3.*
Buff. F. Co. High Gr'd Man	†2.71	......	......	......	†3.51	*3.28*	7.18	......	......	......	7.58	*7.*	*8.66	......	......	......	9.58	*10.*
Buff. F. Co. Id. Wht. & Co.	1.68	1.51	1.93	†1.75	†2.00	*1.64*	8.71	7.60	8.52	9.60	9.69	*9.*	*5.00	5.06	4.59	6.01	4.90	*5.*
Burl. R. Co. Animal Brand	2.74	2.80	2.95	2.81	2.55	*2.*	(b) 4.66	(b) 6.44	5.32	4.41	5.80	*5.*	3.82	4.10	4.50	4.13	4.58	*4.*
Burl. R. Co. Spec. Potato..	......	2.91	2.95	2.67	2.77	*2.47*	......	6.76	5.06	3.65	4.14	*5.*	......	5.42	7.34	6.62	6.96	*6.*
Coe-Mort. Col. Corn & Pot.	1.46	......	1.26	†1.26	†1.49	*1.23*	8.70	......	8.06	8.96	9.24	*8.5*	*2.57	......	2.43	2.56	3.40	*2.5*
Coe-Mort. Gold Brand.......	†2.56	†2.00	†2.42	2.76	†2.50	*2.4*	8.76	5.52	8.05	8.33	8.06	*8.*	*6.06	9.40	5.67	5.69	6.76	*6.*
Coe-Mort. H. G. A. B. Super	†2.14	......	2.03	†2.17	1.93	*1.85*	(c) 9.00	.....	(c) 9.74	10.10	8.36	*8.*	*(c) 2.40	......	(c) 2.84	3.22	3.30	*3.*
Coe-Mort. N.E. Corn & Pot	1.04	0.93	†1.19	1.15	1.21	*0.8*	8.60	5.72	8.84	8.45	7.96	*7.5*	*3.16	*3.26	2.84	2.74	3.08	*3.*
Coe-Mort Prize Gr. & Gr...	......	... ..	......	......	......	.....	11.50	......	11.18	12.18	9.78	*10.*	*2.03	......	1.64	1.49	2.02	*2.*
Coe-Mort Sp. Pot. & Fruit	......	......	......	......	†1.58	*1.65*	.. ...	......	......	......	7.96	*8.*	......	......	......	......	11.48	*10.*
Essex A 1 Superphos.........	......	......	1.14	1.70	1.40	*1.2*	......	......	8.42	7.68	7.28	*7.*	......	......	2.13	2.76	2.56	*2.*
Essex Comp. Corn, etc......	......	.....	†3.13	3.13	†3.27	*3.28*	......	......	6.10	6.08	6.19	*6.*	......	......	10.44	11.91	10.70	*10.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

(b) Available phosphoric acid guaranty, 4 percent.

(c) Available phosphoric acid guaranty, 9 percent; potash guaranty, 2.25 percent.

ANALYSES OF LICENSED FERTILIZERS—1906-1910

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar
Essex Comp. Potatoes, etc..	......	......	†3.44	†3.30	†3.29	*3.25*	......	......	5.58	6.70	7.01	*7.*	......	......	10.80	10.17	10.10	*10.*
Essex Grass and Grain......	......	......	1.02	1.13	1.14	*0.82*	......	......	9.08	8.27	8.60	*8.*	......	......	4.46	4.51	3.94	*4.*
Essex Mar. Garden & Pot..	......	......	1.98	1.95	†2.42	*2.*	......	......	7.93	8.08	8.11	*8.*	......	......	5.55	5.48	5.47	*5.*
Essex XXX Fish & Pot....	......	......	2.10	2.21	2.32	*2.*	......	......	9.14	8.30	8.43	*8.*	......	......	3.04	3.16	3.20	*3.*
Lister's G. Brand.............	1.19	0.88	0.98	1.12	†1.26	*0.82*	8.70	8.64	8.16	8.10	8.74	*8.*	4.02	4.03	3.94	4.17	4.68	*4.*
Lister's Grain & Grass Fert	......	......	......	......	......	......	......	......	......	......	10.24	*10.*	......	......	......	... ..	2.21	*2.*
Lister's Grass and Oats......	1.05	......	0.95	1.05	†1.30	*0.82*	8.18	......	8.05	8.27	8.38	*8.*	4.16	......	3.70	4.90	4.33	*4.*
Lister's Oneida Special......	0.91	0.98	0.98	1.04	†1.21	*0.83*	7.04	7.70	7.34	7.82	7.66	*7.*	1.24	1.17	1.33	1.50	1.57	*1.*
Lister's Potato Manure......	†3.51	†3.68	†3.61	†3.79	†3.64	*3.29*	8.48	9.28	8.75	8.46	8.28	*8.*	7.07	7.00	7.26	7.44	6.43	*7.*
Lister's Special Corn Fert..	†1.75	1.82	1.79	†1.89	†1.51	*1.23*	8.62	8.42	8.55	8.10	8.40	*8.*	3.46	3.30	3.49	3.30	3.48	*3.*
Lister's Special Pot. Fert...	†1.75	1.79	1.89	1.88	†2.23	*1.65*	8.66	8.12	9.07	7.75	8.10	*8.*	3.13	3.18	3.35	3.78	3.51	*3.*
Lister's Special 10% Potato	†2.00	1.72	1.79	1.91	†2.00	*1.65*	9.34	8.46	9.80	8.61	7.92	*8.*	10.01	7.97	10.41	10.93	11.02	*10.*
Lister's Success Fertilizer ..	1.40	1.40	1.30	1.44	†1.37	*1.23*	10.02	9.08	9.42	9.58	9.40	*9.*	2.20	2.50	2.24	2.14	2.55	*2.*
Lowell (Swift's) Animal...	2.53	2.42	2.46	2.74	†2.56	*2.47*	10.06	8.28	8.32	8.62	8.14	*8.*	4.18	4.35	4.15	4.42	4.14	*4.*
Lowell (Swift's) Bone Ft..	1.93	2.00	1.72	1.51	†1.95	*1.64*	9.30	7.77	8.44	8.18	8.94	*8.*	3.24	3.24	3.26	3.38	3.13	*3.*

*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

Lowell (Swift's) Cereal......	0.95	1.16	1.02	1.00	0.90	*0.83*	6.52	7.84	7.32	7.61	7.26	*7.*	1.16	1.64	1.57	1.44	1.30	*1.*
Lowell (Swift's) Empress..	1.44	1.30	1.37	1.47	1.37	*1.23*	7.62	7.54	7.34	7.84	7.52	*7.*	2.09	2.01	2.23	2.19	2.47	*2.*
Lowell (Swift's) Pot. Man..	1.75	1.79	1.74	1.89	†1.81	*1.64*	8.12	7.38	7.78	7.48	6.86	*7.*	4.34	3.02	4.08	4.12	4.06	*4.*
Lowell (Swift's) Pot. Phos	2.49	2.24	2.70	2.50	†2.49	*2.46*	8.20	8.79	7.66	8.26	8.48	*8.*	6.28	*5.30	5.67	6.75	6.53	*6.*
Lowell (Swift's) Spec. Pot	......	......	......	......	2.64	*2.46*	......	......	......	......	6.64	*6.*	......	.....	......	......	10.44	*10.*
Lowell (Swift's) Sterling ..	0.98	0.84	1.02	1.12	1.12	*0.82*	8.66	7.84	8.21	8.44	9.14	*8.*	3.62	4.28	4.06	4.10	4.10	*4.*
Lowell Swift's Superior.....	†3.96	†3.79	†3.86	†3.89	†4.03	*3.7*	8.76	7.40	7.60	7.38	7.30	*7.*	9.75	9.75	9.78	9.93	10.04	*10.*
N. E. Complete Manure.....	......	......	......	......	†3.86	*3.28*	......	......	......	......	6.52	*6.*	....	......	......	......	9.83	*10.*
N. E. F. Co., Corn & Grain	1.23	1.40	1.23	1.55	1.58	*1.23*	7.58	7.52	7.06	7.48	7.66	*7.*	2.20	1.88	2.06	2.57	2.20	*2.*
N. E. F. Co., Corn Phos....	1.89	1.82	1.84	1.74	†1.88	*1.64*	9.62	7.76	8.00	8.68	8.62	*8.*	3.25	3.00	3.22	3.18	3.40	*3.*
N. E. F. Co. Peerless........	......	......	0.98	0.98	1.00	*0.82*	......	......	6.89	8.00	7.34	*7.*	......	......	1.23	1.14	1.22	*1.*
N. E. F. Co. Potato Fert...	1.86	1.75	1.89	1.86	†1.88	*1.64*	8.14	7.28	7.12	6.99	7.46	*7.*	*4.13	*3.47	4.06	4.27	3.83	*4.*
P. & P. Co.'s Corn & Gr. Ft	......	......	......	......	1.09	*0.82*	......	......	......	......	8.40	*8.*	......	......	......	......	3.96	*4.*
P. & P. Co.'s Grain Grower	1.12	1.33	1.47	1.49	1.42	*1.23*	8.02	6.66	7.32	6.95	7.50	*7.*	2.02	1.92	2.36	2.10	2.36	*2.*
P. P. Co.'s Plym'h Rock...	2.49	2.62	2.49	2.67	†2.44	*2.47*	8.34	7.75	8.20	7.62	7.80	*8.*	4.11	3.86	4.32	4.50	4.26	*4.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

ANALYSES OF LICENSED FERTILIZERS—1906-1910

BRAND	NITROGEN						AVAILABLE PHOSPHO'C ACID						POTASH					
	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar	1906	1907	1908	1909	1910	Guar
P. & P. Co.'s Potato Fert....	1.72	1.86	1.89	†2.83	1.91	*1.65*	6.96	6.30	6.04	7.19	6.64	*6.*	6.87	7.44	4.16	6.04	6.14	*6.*
P. & P. Co.'s Pot. Grower..	......	......	†2.49	2.57	2.81	*3.28*	......	......	6.26	6.42	6.32	*6.*	......	......	9.69	10.93	9.88	*10.*
P. & P. Co.'s Star Brand....	1.75	1.65	2 24	1.70	†2.07	*1.65*	7.02	7.28	7.16	6.85	7.60	*7.*	(e) 2.78	3.98	4.15	4.30	4.04	*4.*
R. & H. Co.'s Compl. Phos	†(f) 1.47	†(f) 1.16	†(f) 1.12	†1.54	†1.63	*1.5*	(f) 8.86	(f) 8.04	(f) 8.42	7.72	8.50	*7.*	(f) 4.72	(f) 4.66	(f) 4.03	6.10	5.96	*5.*
R. & H. Co.'s Grass & Gr....	2.81	3.33	3.05	3.30	2.59	*2.2*	8.06	6.03	7.12	8.06	10.24	*6.6*	12.66	14.43	10.83	11.10	12.86	*12.*
R.&H.Co.'s New Mkt. Gd.	......	......	......	†1.61	†2.05	*2.*	......	......	......	6.16	7.45	*6.*	....	......	......	10.97	10.67	*10.*
R. & H.Co.'s Oats & Top Dr.	†8.54	†8.21	†8.70	†8.95	†8.23	*8.5*	(g) 5.48	(g) 4.25	(g) 4.83	4.36	6.42	*4.5*	8.02	9.80	10.29	9.31	8.79	*8.*
R. & H. Co.'s Potato Phos.	†2.12	†2.35	†2.24	†2.03	†2.17	*2.*	8.40	9.82	8.82	10.34	9.80	*9.*	5.54	6.29	6.10	5.77	5.48	*5.*
R. & H. Co.'s Sol.Co.G'l Cp	†2.70	†2.35	†2.35	†2.74	†2.88	*2.5*	(h) 6.14	(h) 7.84	(h) 6.40	7.12	7.79	*5.5*	9.25	8.85	9.14	8.94	8.72	*8.*
R. & H. Co.'s Sol. Potato...	†4.35	†4.53	†4.95	†5.42	†5.30	*5*	7.36	7.95	8.48	7.68	7.30	*7.*	*7.38	*6.93	*6.50	*5.60	*5.84	*5.*
R. & H. Co.'s Sol. Tobacco	†5.75	†5.30	†4.55	†4.91	†5.07	*5.*	8.88	9.82	8.04	6.18	7.62	*7.*	*9.61	*10.92	*14.46	*13.91	*10.95	*10.*
Sanderson's Atlantic Coast	......	......	......	......	†2.63	*1.67*	......	......	......	......	5.28	*4.*	......	......	......	......	*4.53	*4.*
Sanderson's Corn Superph.	......	......	......	......	†2.41	*1.67*	......	......	......	......	7.30	*7.*	......	......	......	......	2.89	*2.*
Sanderson's Formula A.....	......	......	......	......	†3.56	*3.33*	......	......	......	......	7.54	*6.*	......	......	......	......	7.25	*6.*
Sanderson's Potato Manure	......	......	......	......	†1.84	*1.67*	......	......	......	......	6.46	*5.*	......	......	......	......	6.69	*6.*
Sanderson's Special 10 %...	......	......	......	......	†2.67	*2.47*	......	......	......	......	5.84	*5.*	......	......	......	......	10.54	*10.*

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*Potash in brands thus marked is largely if not entirely sulphate. †Contained 0.20 percent or more of nitrogen in nitrate of soda (usually) or sulphate of ammonia; or both.

(e) Potash guaranty 2.5 percent. (f) Nitrogen guaranty, 1 percent; available phosphoric acid guaranty, 8 percent; potash guaranty, 3.5 percent. (g) Available phosphoric acid guaranty, 8.0 percent. (h) Available phosphoric acid guaranty, 6 percent.

VII. SOIL CLASSIFICATIONS AND ADAPTATIONS

It is a settled policy at this Station yearly to "feature" some special topic in its main annual fertilizer bulletin. The law provides for the publication of "information in relation to the character, composition, value and use" of fertilizers. A somewhat complete survey of matters in close "relation to" the purchase and use of fertilizers has been made in recent years. Analyses have been printed, comparisons with guaranties instituted, and the relationship of selling prices and money values of the plant food contents discussed; valuations, guaranties and their meaning, brand names and their lack of meaning, the nature, sources and functions of the deficient elements of plant food have been considered; the several brands have been classified; the character, composition, application and use of farm manures have been reviewed; the systems and methods which prevail in the use of plant food have been outlined, and suggestions offered as to amounts and kinds for sundry Vermont soils and crops. All this has been done in the hope that such a survey might aid in placing Vermont farm practice upon a higher plane and a more rational basis. While it is necessary yearly to make and to print analyses and to comment thereon, and advisable annually to discuss the financial phase of the proposition, the special features of bulletins 93, 99, 108 and 116 (1902 to 1905) do not need repetition, at present at any rate, since these bulletins have been widely distributed and are still available on demand.[1]

The more obvious and immediate matter "in relation to" fertilization having been covered, it seemed fitting in 1906 to begin to review matters less closely connected therewith; to pass from the consideration of artificial means of soil betterment to that of natural ones. Consequently the moisture relations of the soil, particularly as regards water control, through irrigation, drainage and adequate tillage operations, were discussed at length in the 1906 bulletin, No. 123. And, in pursuit of the determination expressed therein, to discuss "sundry phases of soil management during the next few years," a review was made in 1907 of soil biology as it relates to fertilization and particularly to the soil nitrogen content; in 1908 of the causes and remedies of soil deterioration; of the methods of renovation; and of the ways by which further soil treatment may improve rather than impoverish, all with special reference to the humus content of the soil and its maintenance; while in 1909 soil physiography was discussed, the fundamentals of soil making, the ways in which during the ages soil has been formed from rock and organic matter.

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[1] Bulletin 116 is largely called for but is available as a loan only, the edition being nearly exhausted. It is expected to reprint as a circular certain portions of this bulletin for use next winter and spring in the buying season.

In further pursuit of the determination above indicated it has seemed worth while this year to discuss at some length the classification of soils and, incidentally, their adaptations. This particular subject is doubtless much less interesting to the students of soils and soil management than are many other phases; yet, dry though classifications are apt to be, their service is distinct as showing nature, origins and relationships, as well as the side lights they throw upon adaptations. Furthermore, the more immediately practical phases of the general subject have been hitherto discussed; the two chapters which perhaps possess the greatest story elements—i. e., soil physiography and soil biology—have been written. This and the remaining issues of succeeding years must needs be more prosaic. The writer hopes, however, within a few years, by the annual issuance of these fragments, to furnish a fairly complete presentation of the general subject. He plans within the next three years to print in this series articles dealing with soil chemistry and soil physics, but is not ready at present to place himself on paper as regards either phase of this subject.

It has not always been found possible in the preparation of the special articles in the annual fertilizer bulletins to present them in as limpid a manner as could be desired. The subject matter, particularly of the article in bulletin 130 on soil biology, of that in bulletin 143 on soil physiography, as well as of the present article, has been necessarily too abstruse to admit of absolute clarity. It has been found quite impossible at times to avoid using technical terms for which there are no popular synonyms. On this account the discussion will often be found difficult for the lay reader to grasp. For the comfort of such are recommended the glossary—pages 733 and following—defining these terms, and the general summary of the article which gives the essence of the entire matter—pages 731-732.

The writer, in proffering the four classifications discussed in the succeeding pages, has made no attempt to devise new ones, or to vary those hitherto proposed. He aims simply to present those already extant in the literature of American soils. They are suggested by men who by their special training are well fitted to formulate satisfactory schemes. He freely acknowledges his indebtedness to the published writings of the various authors named below in the discussion of these several classifications:

1. AS TO ORIGIN.
   Merrill. Rocks, Rock Weathering and Soils, Part V, pages 282-345 (1906).
   Lyon and *Fippin.* Soils, pp. 30-68 (1909).
   Merrill. The Soil: Its Origin and Kinds. Cyc. Am. Agr. I. pp. 331-340 (1907).
   Shaler: The Origin and Nature of Soils. U. S. Geol. Sur. Rpt. 12, pp. 219-348 (1898).
2. AS TO PHYSICAL CHARACTERISTICS.
   Brooks. Agriculture, Vol. I., pp. 29-43 (1901); also condensation of above as appearing in Ohio Sta. Circ. 39 (1905).
3. AS TO USAGE.
   Snyder. Soils and Fertilizers, pp. 17-22 (1905).
4. AS TO RELATIONSHIPS AS DETERMINED BY SOIL SURVEY.
   Whitney. Soils of the United States. U. S. Dept. Agr., Bu. Soils, Bul. 55, pp. 81-241 (1909).

WHAT IS A CLASSIFICATION?

A classification is defined in the Standard dictionary as the "putting together of like objects or facts under a common designation; a process based on similarities of nature, attributes or relations." A class is defined to be "a number of objects, facts or events having common accidental or essential properties." If the writer may venture a definition he conceives that a classification might be defined to be the result of an attempt to arrange things in such logical juxtaposition and sequence as will serve the better to display their inter-relationships.

Now a classification is a man-made affair. It is not an immutable entity, but an elastic sort of a thing. It may be established on this, that or the other basis, according to the purpose which it is meant to serve. Thus mankind is ethnographically classified into races, Aryan, Semitic, Malayic, etc.; theistically, as to religious beliefs, Christian, Mohammedan, Buddhist, Hebrew; politically into parties, Republican, Democratic, Socialistic and the like. Each classification serves a very distinct purpose. Neither one would serve the other's needs. Furthermore, classifications often enjoy only a temporary vogue; for new information disclosing different, perhaps unexpected, relationships, necessitates their revision or betrays their inadequacy or error.

So it is with any attempt to classify soils. There are several such based on relationships as viewed from diverse standpoints. They are all worth while. They do not clash, but on the other hand supplement each other, for they afford one a more all round conception of a soil than otherwise would be gained.

Four classifications are briefed in this bulletin based:

I. On the origin and method of the formation of the soil. (Pages 707-717).

II. On the physical characteristics of the soil. (Pages 717-722).

III. On the usage to which soils are put. (Pages 722-725).

IV. On certain similarities, due in part to the nature of the original materials from which the soils are formed, and in part to the dominant agencies functionating in their formation. (Pages 725-731).

The first of these is the logical, scientific, fundamental one. It is the scheme developed by Merrill upon whose invaluable work the writer leans heavily in his statement on pages 707-717.

The second is, perhaps, a somewhat more practical one, dealing as it does with those textural and structural soil differences which bear vital relationship to soil usage.

The third is akin to the second, and is a strictly practical classification, although perhaps superficial in that it is based solely on usage and takes no account of origin, composition, etc.

The fourth is the classification devised by the Bureau of Soils of the U. S. Department of Agriculture, based upon its soil survey studies in every state, covering an area of five percent of the entire surface of the United States or an expanse of more than 100,000,000 acres.

1. CLASSIFICATION AS TO ORIGIN

Soil was defined in respect to its origin in bulletin 143, page 199, as "a loosely coherent, highly decomposed layer of mineral matter, resulting from rock decay, which furnishes food and foot-hold for plant and animal life, with which is comingled more or less organic matter, mostly of vegetable origin (Merrill)." This thin soil blanket shelters the rock structure the world over, save where it is blown or worn away. Of diverse physical characteristics and chemical composition, sometimes a child of the underlying rock, usually derived from a myriad sources, the gatherings of the wind, the wave and the weather, its many manifestations have received multitudinous local names, more or less descriptive in their nature. However, despite these wide diversities as to formation, it is possible to gather them within a few groups, indicative of their origin and method of formation as follows:

I. Sedentary soils; (soils occupying the site of the parent rock).

II. Transported soils; (soils made through the action of water, wind, glacial action, etc.)

These are sub-divided as follows:

- I. Sedentary[1] soils.
  - 1. Residuary (residual[1]) (soils *in situ*).
  - 2. Cumulose[1] (soils formed largely from gradually accumulated organic debris).
- II. Transported soils.
  - 1. Colluvial (cliff debris).
  - 2. Alluvial (water formed soils).
    - a. Alluvial (modern).
    - b. Diluvial (ancient).
    - c. Paludal (salt marsh).
    - d. Loess[2] (steppe or prairie soils).
    - e. Adobe[2] (certain arid soils).
    - f. Leda or Champlain clays.
  - 3. Aeolian (wind formed).
    - a. Dust.
    - b. Volcanic dust.
    - c. Sand dunes.
  - 4. Glacial (drift soils).

SEDENTARY SOILS

Residuary soils are formed from the rocks which hitherto had lain in the very location which they themselves now occupy and which overlie the deeper and unaltered rock. They are the stay-at-homes, the conservatives among soils. Native, to the manner born, they are not, as are transported soils, a heterogeneous hodge-podge, picked up here, there and everywhere.

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[1] Definitions may aid our understanding of certain terms. A bookkeeper at work at his desk is a man of *sedentary* occupation. If he inherits such portions of an estate as are not willed in definite amounts to other parties, he is a *residuary* legatee. The words residue and residuary (residual) have the same root. Similarly have the words cumulose and accumulate. A cumulose soil is one which has been accumulated.

[2] Also aeolian in origin as found in many countries.

They contain on the contrary nothing foreign to their immediate surroundings. As their name indicates, they are the enduring residues of a more or less thorough leaching and disintegration of the parent rock. It often happens that soil a foot deep may be all that is left of a hundred perpendicular feet of rock, especially if it is a limestone. Merrill[1] cites analyses of limestone rocks and of the residuary clays derived therefrom, wherein the former had in one case lost in weathering all of its carbonic acid, 99 percent of its lime and 90 percent of its iron, magnesia and phosphoric acid, and in another case all of the lime and magnesia and 90 percent of its carbonic acid. Ordinarily the more insoluble materials, silica, alumina, and iron, constitute the bulk of the residue, whatever the chemical composition of the original rocks. Residuary soils tend to be fine-textured reddish clays, although a few gravels and sands occur. There are few, if any, in New England, but they are found in this country mostly south of the glacial terminal moraine and east of the Mississippi.

Cumulose soils differ from other types in being distinctly organic. They may be an almost pure peat or swamp mud. Other soils are mainly silicious (sandy), argillaceous (clayey), or calcareous (limy); but the organic constituents are dominant in cumulose soils while the inorganic constituents are relatively unimportant. They are formed from a gradually accumulated mass of organic matter, mostly the accumulations of plant life, with which are entangled small amounts of true soil (rock) debris. They are the characteristic soils of enclosed and stagnant ponds, of poorly drained fresh marsh areas, found in the moist and cool climates, of the sphagnum moss bogs, peat deposits and the like. Ireland's bogs, such areas as the Dismal Swamp of Virginia and North Carolina, the Everglades of Florida, much of the muskeg country in Northern Ontario and Keewatin in Canada, are of this general character. This type of soil is formed by the growth of thread-like, microscopic plants, as well as of small forms of animal life, which multiply with immense rapidity entangling therein debris and sediment. These organic masses die, decay, settle and shallow the bottom and constrict the circumference of the pond basins in which they grow. Thus they afford a soil upon which the larger marsh plants may thrive, and then later in their turn die and decay, thus still more rapidly hastening the silting and shallowing of the area. Thus in the course of years and centuries, ponds are made into swamps, swamps into ill drained meadows and these ultimately into the better meadows. Sometimes sphagnum moss forms a more or less permanent soil over a marsh or a pond area.

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[1] Ibid. pp. 217, 219.

TRANSPORTED SOILS

Colluvial soils, if soils they can be called, are the cliff debris, a mass of rocks of all sizes from one hundred ton boulders to dust. They may be as a whole the immediate product of an avalanche, or they may have fallen fragment by fragment, being split off and loosened from the cliff, perhaps by frost or heat. Such soils are mostly disintegrated by mechanical means and but slightly, if at all, decomposed by chemical or biological agencies. They are restricted in area and, save as they tend towards the lower end of the slanting mass to grade into soil, are agriculturally unimportant.

Alluvial, (*water deposited*) is the adjective of the noun alluvium. Alluvium is a deposit of clay, silt, mud, or of the finer particles of sand, which forms wherever the flow of a muddy stream is checked, chiefly on flood plains and at river bends and mouths. Alluvial soils are born of and borne by water. They may have been thus formed and moved recently, that is to say within a few years, or their journeys may have taken place ten thousand years ago. The general term alluvial is used to cover all sorts of water borne soils, but is also subdivided into diluvial (meaning soils deposited in ancient times), into paludal (salt marsh soils), and into alluvial (modern water formed soils).

Alluvial soils as a class differ markedly from those which are formed by gravity (colluvial). They are usually more or less stratified by water action. They consist largely of the finer sands, clays and muds formed from disintegrated and weathered particles of quartz, feldspar, hornblende, etc. Alluvial soils are largely river deposited. The immense loads of mud thus borne towards the sea are in part dropped along the river banks especially when the streams meander. They are the best of soils. The method of their formation, their physical and chemical properties, and the periodicity of their deposition, account for their high quality.

Most rivers flow somewhere in their course through level plains which they overflow during times of freshet. When at such times the water leaves its channel its speed is checked, its carrying power lessened, and it drops more or less of its load, if it carries any, upon the flood plain, which is thus permanently enriched by the silt deposit.[1] The Mississippi Valley is an alluvial formation. Egypt were uninhabitable were it not for the annual overflow of the Nile, which for at least 4,000 years, and doubtless many more, has thus fertilized with silt from the Abyssinian mountains, a narrow strip of land on either side, which otherwise were a desert.[2]

Alluvial soils are forming in myriad lakes and glacial ponds throughout New England and to the North. Thousands of meadows, swales, swamps and intervals in glaciated regions have been thus formed. There are several stages in the evolution of such a meadow. A clear water pond with entrant and exit streams, the former bringing in silt which tends to shallow the water; aquatic plants growing in the sheltered portions, and catching silt, which decay and fall; plant, tree trunks, etc. entangling yet more silt, thus tending to encroach on the shores, and slowly to constrict the circumference of the pond; until finally it evolves into a flat plain frequently inundated, but gradually rising until there is formed a meadow and a stream meandering through it. Thus the stream which originally gave the pond its birth is a factor in ultimately extinguishing it. Many New England ponds are simply transient enlargements of streams which, in the course of the ages, are destined to become meadows. Where we fish, our hundreth removed great grandchildren may play golf. The later stages of this process closely resemble the formation of cumulose soils already described (page 709-710) and bear relation moreover to the formation of marsh soils, about to be described.

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[1] Bulletin 143, pages 216 to 229, discusses in detail the effect of water upon the disintegration of rock structure and its relation to the formation of soil. It reviews the various processes of erosion, transportation, corrasion and deposition, the ways in which the rock structure is worn away and the separated particles borne away by water, as well as the manner in which they are laid down as soils. In short the formation of alluvial soils has been in part discussed in a previous issue in this series, to which the reader is referred.

[2] In this connection see Vt. Sta. Bul. 143, pp. 227-228 (1909).

Paludal soils (salt water marsh) are formed in part from plant growth and in part from inorganic matter secured through the transporting and assorting power of tide and wave action. The configuration of the coast at a given point determines whether or not a marsh will be formed. "The breaking waves dashed high, on a stern and rock bound coast" of New England; and their dashings tend to break away and to wear away the exposed headlands, and to carry the rock debris thus made into the intervening inlets, where it is thrown upon the beach. Here it becomes ground to fine sand and mud. Constantly in motion, the waves hurl the rock particles onward and the undertow drags them backward, and continual wear results. Sea-beach sand rarely consists of sharp cornered particles. They are worn away and are often "beaten to a frazzle," forming mud. Much of this is carried by the tidal flow into the fjords, harbors, tidal estuaries and the like, where it falls to the bottom, or is conveyed yet further and dropped in the inlets near the shore line.

As soon as a sheet of mud forms, eel grass grows thereon beyond the low tide level, thus entangling yet more sediment. The tide, as is well known, ebbs and flows twice in 24 hours. As its movement is checked four times daily, it tends to drop its silt upon the mud flats. Mud, seaweed fronds, eel grass, shells, pebbles, the refuse of dead fish, etc., all help to grade up the marsh. The process is a relatively rapid one and in due time some of the soil thus formed appears above the low water mark. Then eel grasses and seaweeds are replaced by those forms of plant life, low grade grasses or sedges, which grow between high and low water mark. These entangle still more debris, and serve still higher to raise the level of the newly formed soil, until finally it is lifted above the reach of all save the highest tides, when diverse types of salt marsh grasses replace inferior plants.

Paludal soils in their natural condition are of but little agricultural importance, but when reclaimed they make fertile soils. Many millions of acres of paludal soils exist. Immense areas have been reclaimed from the sea and made arable. A classic example of such reclamation is to be found in Holland, a land largely reclaimed from the sea. Thousands of acres were rescued a generation or two ago near Grand Pré, Nova Scotia. Doubtless there are a quarter million reclaimable acres along New England's coast. A successful attempt was made in 1874-5 to reclaim the large area of salt marshes in Marshfield, Mass. However, the dikes were injured by a severe storm some twelve years ago, and much of the diked land claimed again by the sea. It is estimated that large areas could thus be reclaimed at many points along the Atlantic coast, at a cost not to exceed one-fifth the value of the improvement. Work is now being done under government auspices looking towards the wholesale reclamation of paludal lands. In other words, the United States Reclamation Service is concerning itself not only with the supplying of water to arid soils by way of irrigation, but with the withdrawal of water from ill drained soils by underdrainage, and such diking of the soils of the sea as will serve to keep out the tides and to make agricultural soils of the salt marsh areas.

Loess. The term loess is loosely used to designate soils having many physical properties in common, but varying widely in composition and as to the method of their formation. It is often, and sometimes improperly, applied to steppe or prairie soils. Loess is sometimes of aeolian origin, sometimes an alluvial soil; but, whatever its origin, it is ordinarily an extremely fine silt or clay. It occurs all over the world; in the Mississippi valley, on russian steppes, in China, in many portions of Europe, both eastern and western. The immense chinese deposits are largely aeolian or wind formed; those of the western prairies are held by some to be of alluvial origin; by other to be aeolian. The former, covering tens of thousands of square miles, thousands of feet thick, is a fine detritus borne by rain and wind from the mountains to the lower levels, a calcareous yellow silt or clay, readily powdered, yet so tenacious as to resist weathering and to stand upright in high cliffs, though cut in every direction with deep gorges.

Loess soils in general are very absorptive, retentive and fertile. In China they have stood cropping for at least three thousand years without exhaustion. Thousands of square miles in the Mississippi drainage basin are extraordinarily fertile and hundreds of feet deep. Surface and subsoil differ but slightly, either in texture, structure or in inorganic composition. The humus content of the former is apt to be high in humid regions, but to be less under arid conditions. The loess is well adapted to the growth of corn, cereals and, often, of alfalfa, and because of its high absorptive powers, makes better use of the waters supplied either through rainfall or irrigation than do most soils.

Adobe. Adobe soils are more clayey and less silt-like than is the typical loess. A very fine, porous, calcareous clay, friable and standing perpendicularly like the loess, the term covers materials quite unlike as to their mode of origin and composition, but alike in physical characteristics. The soil of much of the rainless region of the United States is of this type. It is sometimes from two to three thousand feet deep and varies from buff to gray in tint. It is fertile because it is deep, because there has been but little chance for the leaching of its fertility by rainfall.

It is rich because its initial fertility has been retained, it having been but slightly cropped owing to arid conditions, and because of its high lime and alkali contents. One should not understand, however, that in its natural condition adobe is a fertile soil. It is frequently overcharged with plant food, is alkaline, and, lacking water, is a desert. When watered, however, it blossoms as the rose. The popular conception of a desert is that it is such because of lack of plant food. This is often an incorrect idea, the fact being that it is very fertile but, lacking water to render the plant food content soluble, crop growth is impossible.

Leda or Champlain Clays. These are accumulations from depositions sorted from glacial debris by running water and laid down in what is known geologically as the "Champlain period," when the waters became quiet again after the glacier had melted. These are the well known clays of the Champlain valley, found also abundantly in the lower valleys of the principal rivers of New England and elsewhere, either on the surface or overlaid with sand or more recent soils. They constitute the plains of lower Quebec to the mouth of the St. Lawrence, are from 50 to 100 feet thick and are an impalpable, fine, plastic, unctuous, bluish gray clay, which hardens and bakes in drouth and which is plastic and uncultivatable when wet. The Champlain clays contain relatively high percentages of plant food, but their physical properties are far from ideal.

AEOLIAN SOILS (WIND FORMED SOILS)

That the wind may be a real factor in soil formation may not be apparent at first glance; but it has been such in many sections of the world. Both dust and sand are wind blown. The dunes along the sand beach, indeed in many parts of Vermont (Castleton, Lyndon and elsewhere), as well as in the desert, evidence its work, although such wind gatherings are not apt to be or be capable of becoming arable soils. Every raindrop, each snowflake, bears its load of dust. The clarity of the air after a storm is due largely to the dust being washed out of it and onto and into the soil. The Chinese loess is doubtless of aeolian origin, and that of the central plains is thus ascribed by some (page 714). In fact the origin of all the loesses and adobes, whether alluvial or aeolian, is debatable and in controversy.

The dust brought from the air by wind, rain or snow is partly of volcanic origin; partly rock fragments formed by the etching of wind driven sand and is partly organic.[1]

GLACIAL SOILS (DRIFT SOILS)

These soils result from glacial action, although their immediate deposition is in part due to the effect of water flowage. The effect of the great glacier of prehistoric times upon New England topography and soil conditions was discussed in detail in bulletin 143, pages 230-236. The changes wrought by erosion, the methods of drift deposition, and its nature are developed at considerable length. It was there shown that no native soil exists on many millions of square miles of the Northland; that the soil blanket, with which the hard, smooth, scratched rock is overlaid bears no relationship thereunto in composition or in structure; that the soil is as truly foreign to the underlying rock as would be an orange grove in Greenland. There are practically no sedentary soils in New England (see page 709). Its stone walls may be built of granite upon a limestone soil or the reverse. Its multitudinous loose rocks and boulders have mostly journeyed from the northwest by the glacial route. Its soil is a heterogeneous confusion of boulders. pebbles, cobbles, sand gravel, clay, dust, organic matter, etc., its nature depending largely upon the character of the original rocks to the northwest.

These glacial soils were moved in some cases for long distances, in others for relatively short distances. Some are unassorted; the heterogeneous mixture just mentioned; others are assorted having been laid down by subsequent water action and become more or less stratified. The technical name of a glacial soil is "till." Its depth may range from 30 to 500 feet, but from the nature of its formation it is ordinarily a relatively shallow soil. Often it has been bettered by glacial action and frequently impaired. In areas where the drift is notably stony, as is often the case in New England, farming operations are made correspondingly difficult. But the soils of Illinois, Minnesota, the Dakotas, etc., many of them of glacial origin, are notably and notoriously fertile. The coarser glacial soils are usually of a poor type; the finer soils are strong though apt to be cold and heavy and frequently in need of underdrainage. (See bulletin 143, pp. 230-236 for a more detailed discussion).

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[1] In this connection see bulletin 143, pages 206-208, dealing with the eroding effects of wind blown sand and dust in rock disintegration and soil formation.

2. CLASSIFICATION ACCORDING TO PHYSICAL CHARACTERISTICS

In this soil grouping such difficult words as cumulose, colluvial, loess and the like are forgotten, and such simpler terms as sand, humus, loam, are used. It might be called an agricultural classification, because, like the next one, it bears a very close relationship to soil usage.

Soils are classified in this grouping as:

(a) Gravels.
(b) Sands and sandy loams.
(c) Silt and silty soils.
(d) Clay and clay loams.
(e) Humus and humus soils (loams).
(f) Marls.
(g) Alkali soils.

Concerning these various groups it may be said:

(a) *Gravel* consists simply of rock particles so large in size as to possess no agricultural value save for road making.

(b) *Sand* consists of rock particles smaller than gravel, yet large enough to be seen by the naked eye. The mineral quartz, of which most sand particles are made, is a very hard material, one which is but slowly affected by weathering, relatively insoluble and containing but little plant food. Sand particles may be of all sizes, from those hardly smaller than fine gravel to those that are barely discernible to the unaided eyesight. It is commonly graded into groups, denominated coarse, medium, fine and very fine sands. The proportions of these various groups in a given soil affect its service for crop growing purposes, more particularly because of the relation they bear to soil temperatures and to soil moisture and because of their varied crop adaptation.

Sands as a class are too coarse, too porous to be ideal soils. Their humus content decays too readily because of their porosity and their too ready inlet of air. They are heavy soils, i. e., heavy in weight, but they are also light soils, i. e., easy to work.

If a soil contains 90 percent or more of sand, it is so classified. If it carry 80 percent to 90 percent, it is designated a sandy soil or a light sandy loam. Such a soil is apt to have but little agricultural value, unless the finer sizes of sand particles are in great preponderance. Such soils do not readily retain the more soluble forms of plant food, either such as may be inherently present, or are applied in the shape of manures or fertilizers. If such soils are fertilized heavily with organic manures, such as barnyard manure, or peat, or if green manuring is practised, their retentive powers are improved.

Light sandy loams are usually unsafe soils, unless located in a region of plentiful rainfall during the growing season, or where water is available for irrigation purposes. If not thus located, crops thereon suffer in drought by weather. They are relatively lacking in plant food and do not retain artificial supplies well, but they may be used under certain favorable circumstances for such early market crops as melons, tomatoes, and the like, for which a ready market is at hand and high prices obtainable.

Sandy loam are loams (see page 720) containing humus, clay, silt and the various grades of sand, the latter being in preponderance. Their high power of heat retention well fits them for the growth of truck crops. They are porous, easily worked, do not crack or pack as do the clay soils, but the crops grown thereon are much more prone to injury from drought than are those grown on soils of a clayey type. They are especially adapted to the growth of truck crops, particularly the early varieties, corn, certain root crops, melons, squashes, potatoes and the like. If not too sandy they are well suited to the growth of legumes, particularly clover and alfalfa.

(c) *Silt* is a term applied to an intermediate sized particle, located between the very fine sand and clay. As with the sand different grades are recognized, coarse silt and fine silt, grades based upon the varying size of the particles. Being a relatively fine textured soil, a silt commonly retains water well, yet not so well as always or usually to necessitate underdrainage. Its plant food content is apt to be relatively high and, because of its fine texture, this is more available to plant uses than that possessed by a soil made up of larger soil particles. Silt is one of the most valuable of soil types.

(d) *Clay* is a term applied to soil particles too small to be visible to the naked eye, too small, indeed, to be felt as grit when rubbed between the fingers, impalpable, so small that several thousand placed side by side would not span an inch. Clay is commonly derived from feldspatic or slaty rocks and consists largely of silicate of alumina. The particles lie closely together and the spaces between them are extremely minute; hence clays are relatively impervious to air and water, are very adhesive, puddle readily and, when dry, pack into hard, compact solid clots, which are rock-like in their character and difficult to crush. Clay soils are obviously hard to handle, and, if the clay is in excess of 90 percent, they are intractable and impossible. In times of drought they crack seriously and are apt to tear plant roots, which later become dried and injured because of the air. Unless underlain a few feet down by a more open and porous soil—a condition which does not commonly exist—clay soils are apt to be wet and cold. If the proportion of clay is not so high as to make the soil impossible because of physical deficiencies, its very fineness and retentiveness tend to make it extremely fertile. Grass and cereals, as a class, are apt to do well, although suffering in extreme seasons of either sort. Many soils thought to be of a clayey type are often composed largely of silt. The more workable heavy soils are usually of that character.

Clay loams are often very fine types of soils. The heavy clay loams possess many of the faults of the clays in that they are over-retentive of water, too cold and not well aerated. However, they hold supplied plant food readily as against leaching and are not readily affected by droughts because of the fact that the fine texture inhibits rapid percolation. They are, moreover, apt to be rich in potash. If carefully cultivated, crusts are not apt to form. They are best suited to such crops as grass and wheat. Clay loams, as apart from heavy clay loams, are more workable soils, compact, are apt to crack, but being rich in plant food, and not prone to lose the same by leaching, are excellently adapted to the growth of grass and cereals.

(e) *Humus and Humus Soils.* (*Loams*). The word loam is an indefinite one. It is stated in the dictionary to be a "non-coherent mixture of sand and clay containing also calcium carbonate and organic matter." A loam soil is an indeterminate soil, neither one thing nor the other, practically the only soil which mechanically neither preponderates as a clayey nor as a sandy soil. Yet a loam is apt to be a high grade soil; the word is a synonym for richness. A true loam contains considerable amounts of humus, more so than does either a clay or a sand. Loams as a class hold water readily and permit it to move easily; they tend to be relatively rich in plant food, are well aerated, readily worked, neither crust nor crack and are well suited to crops in general, particularly such as use large amounts of water. There is almost no crop but what is adapted to growth on loams.

Bulletin 135, issued two years ago, discussed at length soil deterioration and soil humus. The nature of humus, its relationship to soil condition, and to soil usage, the benefits, chemical, physical, and biological it confers, and the methods of its maintenance and increase: all these matters were gone over in detail. Twenty or more pages devoted at that time to this subject are deemed sufficient; so that there is little need of further review in this issue.

(f) *Marl.* A marl is a deposit of amorphous material, composed mostly of various proportions of clay, sand and, ordinarily, calcium carbonate. According as marls differ in constitution, containing relatively more clay on the one hand or more sand on the other, or are more limy in their character, they are termed clay marl, sand marl, greensand marl, or shell marl. Perhaps the more common marls are the shell marls, the bulk of the material being made up of extremely minute shells of ancient origin. The calcareous or shell marls, which are the more common kinds, sometimes contain as high as 90 per-cent of carbonate of lime, mixed with more or less sand, silt or clay. A belt of greensand marl, containing a considerable amount of potash, extends diagonally across New Jersey and is largely used in the vicinity as a fertilizer.

Marls as such are not agricultural soils, but are soil amendments. They are frequently well worth using where soils need lime or potash; or, in case they are clay marls, they may be used at times to correct the physical unhappiness of a too sandy soil. Their effect is due partly to physical and partly to chemical modifications, the former being induced more particularly by an increased retentiveness of the soil.

Marls vary enough in character, so that unless one knows by analysis, by observation or by previous experience the nature of the material he is handling, the results to be expected from a given application may not readily or accurately be predicted.

(g) *Alkali Soils.* An alkali soil is one which contains noticeable, even injurious, amounts of free and soluble plant food. They are found almost exclusively in arid and semi-arid regions. They have marked peculiarities, due to the relative lack of drainage and to the carriage of dissolved salts, particularly sodium salts, to the surface by capillarity, where, upon evaporation of the water, the alkaline salts are left as a crust. In regions where rainfall occurs in sufficient amount these soluble plant foods remain in solution and such as are not absorbed by vegetation are washed out into the drainage. The reason why the sea is salt, why salt lakes occur in desert basins, and why many waters are hard, is because of the presence of these plant foods in these waters. In arid regions and in valleys and basins whence there is no access to the sea, these materials cannot be thus removed and necessarily must accumulate. Furthermore, under the torrid conditions of these climates many of the chemical changes of weathering go on very rapidly, the rocks break down with readiness and the soil particles speedily become disintegrated; another reason for the rapid accumulation of these alkaline salts.

Such soils are not always beyond remedy. The salts may be washed out of a soil by irrigation waters supplemented by under-drainage and to some extent sulphate of lime may be used as a corrector. Alkali soils are a very serious menace to western agriculture, but they are not factors in eastern agriculture owing to an ample rainfall; hence further treatment of them in this connection may be omitted.

3. CLASSIFICATION ACCORDING TO USAGE

A third soil classification, and an eminently practical one, is suggested by Snyder, an l is constructed in accordance with the usage of the soil, whether it be specifically adapted for the growth of grass, corn, wheat or what not. Of course any classification of this kind is necessarily an extremely elastic and even superficial one. The same classification could not be used for instance in Siberia and in India. However, for the conditions of the generality of the northern portion of the United States, one may classify soils in a general way, advancing from the coarser to the finer textured soils as: (a) Early truck and potato soils. (b) General truck and fruit soils. (c) Corn soils. (d) Grass soils. (e) Wheat soils.

(a) *Early Truck and Potato soils.* To grow market garden crops in a satisfactory manner and to get them in the market early enough to warrant a good price, one needs a notably warm soil. The better types of this class of soil usually contain relatively large amounts of sand and small amounts of clay. Snyder, whose discussion of this matter is being followed in this particular portion of this article, suggests that the better types of early truck and potato soils are apt to contain about 60 per cent of medium sand, from 20 to 25 percent of silt, perhaps about 5 percent of clay, and that, when carrying 3 percent of silt, they hold from 5 to 12 percent of water. He points out that when these crops are grown on soils containing much more water than this, they are apt to be slow in maturing. When used for the production of early market garden crops and as one gets further north, the proportion of sand may relatively increase, and of silt decrease. Soils like this are not apt to be naturally as rich in plant food as are some of the other types, but are of a nature to make admirable use of large quantities of added plant food.

(b) *General Truck and Fruit soils.* Where extreme earliness is not a factor, and where water constitutes a large percentage of the market crop, as in market garden crops and fruit, more of clay, rather less of sand and, consequently, a greater water-holding capacity are to be desired than when early truck is grown. From 10 to 15 percent of clay, 50 percent of sand, and 10 to 18 percent of water are preferred. Great divergence of practice is observed, particcularly in the growth of fruit. Some fruits succeed admirably on soils with a large percentage of clay; others on soils such as those now under consideration.

(c) *Corn soils.* The corn crop originated in tropical regions. The highlands of Mexico are considered to be its birthplace. It is still a warm weather crop and needs a relatively warm soil for its best development. Yet, on the other hand, it is an avid user of water. Hence the better types of corn soils contain relatively large amounts of the finer types of sand, mediums amounts of clay, and have rather high water-holding powers. Snyder[1] mentions 40 to 45 percent medium and light sand, 15 percent of clay, and 15 percent available water content as ideal for this purpose. The heavier types of soils may grow larger gross yields, but are not so likely to mature them. They require more cultivation and, for northern latitudes, are not as a rule to be advised, because slow to warm up. On the other hand, if the percentage of sand is materially larger than that mentioned above, there is likelihood that too little water will be held, that the growth of the crop may be stunted and that a too early maturity will ensue. The corn soils of the western corn belt states are, as a class, of a silt character, a type of soil which it will be remembered is intermediate between the sands and clay.

(d) *Grass soils.* Grasses and grains use more water than does corn. The corn is planted in rows, whereas grass and grain are drilled or broadcasted. Their yields are determined very largely by the amounts of available water. Ideal soils for grass and small grains are more close textured than for corn, should hold normally 20 percent of water, should possess more silt and less clay than do corn soils, and less sand. In general the heavier types of soils, yet not the heaviest, are best adapted for these purposes. Light silt soils form the bulk of the grass and grain areas of the country. Sixty percent of silt and 15 percent of clay are said to be ideal, although soils carrying less silt and more clay under some circumstances have been used to advantage.

(e) *Wheat soils.* Wheat soils are the finest types of soil, using the term in the textural sense. Thirty or even 50 percent of clay may be contained therein to advantage to the crop under some circumstances, although if fine silt replaces the clay frequently as good yields are attained. A great variety of soils is found in the wheat sections, but whatever the mechanical analysis of the soil it should be such as to contain at least 20 percent of water. If this figure is not maintained the crop is apt to be correspondingly lowered. Of late years wheat has been freely grown in the relatively rainless regions of Western Nebraska and Kansas. Varieties grown there, known as the duram or macaroni wheats, are so structured as to withstand drought much better than the ordinary wheat and to make a satisfactory growth on a relatively small water usage.

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[1] Soils and Fertilizers, page 19.

4. CLASSIFICATION ACCORDING TO THE SYSTEM OF THE BUREAU OF SOILS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

The Bureau of Soils of the National Department has been making soil surveys and soil maps of various areas in all parts of the country for a dozen years. It has now surveyed and mapped over 100,000,000 acres, widely distributed in over 300 locations, or a total area in excess of five percent of the entire country.

Up to January, 1908, it had grouped 715 different types of soils. From coarse textured to fine textured, from sandy loams to clays they number: stony loams and clays 45, shale and slate loams 9, gravelly loams 62, sands 48, fine sands 31, sandy loams 74, fine sandy loams 90, loams 122, silt loams 80, clay loams 68, clays 76 and unclassified 10. Of the 94,000,000 acres then surveyed, 42,000,000 in round figures are deemed to be agriculturally of the first rank, 26,500,000 of the second rank and 22,000,000 of the third rank, while 3,500,000 were non-agricultural lands; while 164 of the 715 types were classified as of first rank, 271 of second rank and 270 of the third.

Obviously in this large volume of work there has been encountered many hundred soil types, differing more or less from each other in appearance, in physical condition, texture, structure, composition, and otherwise. Attempts have been made to arrange these various types in series so as to display their interrelationships. Futhermore, for working purposes, the country has been divided into a series of so-called "soil provinces." These soil provinces, 14 in number, coincide roughly, but not exactly, with the physiographical provinces now commonly recognized.

It were both impossible and unnecessary to go into the details of this vast amount of work. A recent departmental bulletin[1] details the matter in a very clear and succient form. However, any attempt nowadays at a review of soil classification which did not at least refer to this monumental work would be faulty.

The various soil provinces as listed by Whitney[1] are:

1. The Atlantic and Gulf coastal plains, extending from Long Island along the seashore.

2. The river flood plains, as of the Connecticut, Merrimac, Mississippi, Ohio, Missouri, etc.

3. The Piedmont plateau lying to the west of the Atlantic coastal plain and to the east of the Alleghany plateau, extending from upper New Jersey to mid-Alabama.

4. The Appalachian mountains and plateaus, covering the territory from Pennsylvania through Western Virginia, North Carolina, Eastern Kentucky and Tennessee, and down to Alabama.

5. The limestone formations and uplands in Kentucky and Missouri.

6. The glacial and loessial regions, covering all the territory to the north of the terminal moraine; all New England, New York, the territory north of the Ohio River and, roughly, of the Missouri River, save such as is embraced in the next province.

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[1] U. S. Dept. Agr., Bu. Soils, Bul. 55 (1909).

7. The glacial lake and river terraces around the borders of Champlain and the Great Lakes and in Northern Minnesota, covering the area around the prehistoric and long lost Lake Agassiz.

8. The residual western prairie soils in Kansas, Oklahoma and Texas.

9. The great basin of Nevada and portions of Utah.

10. The northwestern intermountain region of Washington, Oregon and Idaho.

11. The Rocky mountain valleys and plains, covering the region, roughly, from the 101st to the 111th parallell.

12. The western mountain regions, practically non-arable and almost uninhabited.

13. The arid southwest in lower Arizona and California.

14. The Pacific Coast valleys, extending inland in a broken chain from Puget Sound to Mexico.

A number of soil series are recognized in each soil province, each series being made up of a set of type soils. Thus for example, in the glacial and loessial regions have been recognized the so-called Marshall, Miami and Volusia series; and there are a number of miscellaneous soils which cannot be relegated to any particular series. Similarly among the soils of the glacial lakes and terraces are recognized the Clyde, Dunkirk, Fargo, Hudson, Merrimac, Superior and Vergennes series, as well as several miscellaneous and unassigned soils. A series is usually named after some prominent town in the area which has been under survey. Each series usually contains a number of soils as, for instance, the Vergennes series, which consists of stony loam, gravelly loam, fine sand, sandy loam, loam, black clay and clay. As typical of this sort of classification the following statement concerning the Vergennes series, the only one which belongs particularly to Vermont,[1] is reprinted from Bulletin 55 of the Bureau.

"The Vergennes series occurs on the terraces surrounding Lake Champlain. It consists of deep-water sediments known as the Champlain clays, deposited in post-glacial times over glacial drift during a period of submergence. Since the uplift these clays have been more or less modified by stream action and colluvial wash from soils of the surrounding highlands derived from the underlying geological formations, usually sandstone, shale, and limestone, and in limited areas by wash from glacial drift soils. The series is characterized by brown, yellowish, or grays soils, underlain by drab to light or light-gray clay subsoils at varying depths. The surface is level to gently rolling, and for the most part artificial drainage is necessary.

The clay is the most extensive, as well as the most important, of the Vergennes soils. It is a heavy soil, one which requires careful and painstaking cultivation to secure the best results. Its heavy texture makes it admirably adapted to the production of hay, and this constitutes the leading crop. It is not an ideal corn soil, but profitable yields of this grain, as well as of oats and barley, are secured. The black clay requires drainage and were this done it would be the best corn soil of this section. Good yields of hay are cut from the better drained portions, while the more poorly drained portions are used only for pasturage. The best apple orchards in the Champlain Valley are found upon this type and the fruit produced is of high quality. Soils better adapted to tilled crops militate against the extensive cultivation of this type, most of which is used as pasture or woodland. Certain of the more easily tilled portions are highly esteemed for potatoes. The fine sand is best adapted to truck crops and small fruits, though corn, oats, and hay are grown with fair success; corn, clover and late truck do well on the sandy loam, while the loam is desirable for corn, hay, oats and barley. The gravelly loam is well adapted to potatoes.

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[1] It is not to be inferred that there are not other soils in Vermont; or that many of the types elsewhere found may not exist in Vermont. No doubt many of the types found in the survey of Merrimack County, New Hampshire, and in the Connecticut Valley from the Vermont line south to Hartford, Conn., as well as in New York surveys would be found here; but simply the State as a whole is as yet untouched by soil survey work.

The acreage of the types so far encountered is given in the table."

AREA AND DISTRIBUTION OF THE SOILS OF THE VERGENNES SERIES

Soil name	States in which each type has been found	Total area acres
Vergennes stony loam,	New York, Vermont	17,024
Vergennes gravelly loam,	do.	3,968
Vergennes fine sand,	do.	8,384
Vergennes sandy loam,	do.	2,112
Vergennes loam,	do.	4,352
Vergennes black clay,	Vermont	3,584
Vergennes clay,	New York, Vermont	129,984
Total,		[1] 169,408

The soil provinces of the United States are based, as has already been remarked, partly upon physiographical subdivisions and partly upon the soil pecularities as determined by the various agencies of soil formation. Thus the following tabular statement, modified from a diagram shown on page 107 of bulletin 55 hitherto cited, indicates some of the relationship of the climatic conditions and of the physiographical agencies, discussed at length in bulletin 143 of this Station, to the formation of soils in these various provinces. In short, the classification is based upon certain soil similarities, due in part to the nature of the rocks from which they are made and in part to the nature of the principal agencies functionating in their formation.

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[1] This does not mean that this is of necessity all of the soils of this type in Vermont, but simply that in the total area covered by the soil survey, which extended in this state from Ferrisburg to Shoreham and back from the lake on the average about ten miles, these numbers of acres of these types were recognized.

ILLUSTRATIVE OF PRIME AGENCIES CONCERNED IN SOIL FORMATION IN THE VARIOUS SOIL PROVINCES

Humid Soils (East)

Agencies functionating in forming the several soil provinces	
Heat metamorphosis	Piedmont Plateau
Ice	Glacial and Loessial Glacial Lakes and Terraces
Ocean	Atlantic and Gulf Coastal Plains Limestone Valleys and Uplands
Rivers	River Flood Plains
Topographical modifications	Appalachian Mountains and Plateaus
Arid and Semi-Arid Soils (West)	
Water (Lake)	Great Basin
" (Ocean)	Residual Soils of Western Prairie Arid Southwest
Vulcanism (Volcanic)	Northwestern Intermountain
Topographical modifications	Rocky Mountain Valleys, Plateaus and Plains
————————	Pacific Coast

Bulletin 143 on Soil Physiography so thoroughly discussed the relationship of the several internal and external agencies of rock disintegration and soil formation as to render it unnecessary to repeat what is said there about the relationship thereunto of the effect of ice, water and wind. Little, however, was said touching the fundamental relationship of climate to this matter, and with a few words thereon, this matter will be closed.

The humidity or aridity of the climate is necessarily a controlling factor in soil formation. Speaking broadly, the eastern half of the United States is a humid land; the western half, an arid or semi-arid land. In the east and midwest marked differences may be and usually are observed between soil and subsoil; in the far west, but few such are to be seen. Eastern soils contain relatively considerable amounts of humus; far western soils much less, but what there is is much richer in nitrogen. Eastern soils as a whole are not as deep as are the western soils and many of them are less rich in soluble plant food; but they are much better on that account, for many western soils are over saturated with soluble plant food to such an extent as to be unuseable (see page 721). When irrigated, however, these arid desert soils are apt to be extremely fertile, provided they are not over-alkaline in character. Their great depth, the difference in the root crop systems, the fact that the texture of the subsoil is not usually much, if any, closer than that of the surface soil, thus permitting of deep rooting and a more economical use of water; all these are factors in far western crop growing and are the main reasons why dry farming succeeds in many sections where the rainfall is comparatively light.

The classification of soils according to the Bureau's system is essentially an attempt to determine, so far as may be, soil regions and soil adaptations; or, as expressed by the Chief of the Bureau the desire of its staff through its system of surveys and the classification based thereon is to further "the extension of established industries on soils of known high value for certain crops, and—a more difficult matter—the utilization of soils of unknown adaptations or, perhaps, of inherent qualities adverse to profitable cultivation."

SUMMARY OF ARTICLE ON SOIL CLASSIFICATIONS AND ADAPTATIONS

A classification serves to show the interrelationship of things. Soil classifications are based on:

(1) Origin.
(2) Physical characteristics.
(3) Usage.
(4) Soil survey work.

Each of these several classifications serve very definite purposes and together they afford a more all round conception of the soil than would any one alone.

(1) The classification as to origin divides soils into two great classes, sedentary and transported; the first being those

formed from rocks native to their location, the second from rocks which had been transported as rock or soil from other regions. The main subdivisions are the residuary on the one hand; and the several alluvial, the aeolian and glacial soils on the other.

(2) The classification as to physical characteristics makes seven subdivisions: gravels, sands, silts, clays, loams, marls and alkalies. The difference between these sundry soils are largely physical and in the main pertain to the size of the soil particles. However, there are some subsidiary considerations, such as the humus content, the lime content, the alkali content, which have bearing.

(3) The classification as to usage takes cognizance first and foremost of the service of the soil in the growing of this, that or the other crop, its special adaptations to that end. Consequently it discusses truck, potato, corn, grass and wheat soils, describes them and indicates why their adaptations are as they are.

(4) The scheme of classification propounded by the National Bureau of Soils is based upon a nation wide system of soil surveys. It aims to determine soil divergencies, natures and adaptations, and to promote, as a result of this special knowledge gained by this personal inspection, "the extension of established industries and the utilization of soils of unknown adaptations."

GLOSSARY

Extensive glossaries were printed in bulletins 99, (1903) 130, (1907) and 143, (1909), it being thought that they might prove helpful to their readers. The matter in this issue pertaining to soil classifications and adaptations is inevitably so technical that it seems likely that another glossary may prove useful to the particular class of readers to which this bulletin appeals. No attempt is made to define any term which is not a technical one, save such as are in common usage but bear a technical meaning as employed in this connection. However, the term "technical" is construed liberally and many definitions are included which doubtless are unnecessary. It seems best, however, to err on the side of over-definition than the reverse. The writer has been guided to a large extent in the formulation of definitions by the 1906 edition of the Standard Dictionary.

The words in the definitions which are *italicized* are themselves defined in the glossary, enabling thus the clarification of a possibly obscure definition by cross reference. The definitions are in the main restricted to the special usage of the terms. Exactness of scientific terminology has not been sought, the attempt being rather to make more clear the statements in the main body of the article than to afford complete and comprehensive definitions. No attempt is made to define words having to do with fertilization or with the fertilizer trade. The glossary in bulletin 99 (which is available to any reader who desires it) is thought sufficiently to cover these terms.

In the language of the market, "if you do not see what you want, ask for it." If you fail to grasp the meaning of a word, a phrase or a proposition; if any matter in this bulletin is not clear; or if you wish advice touching any phase of fertilization, soil management, or of agriculture in general, write to the Experiment Station, Burlington, Vt., and answers will be cheerfully returned without charge.

ADOBE.—An extremely fine clay found more particularly in and characteristic of *arid* regions.

AEOLIAN.—Wind formed.

ALKALI SALTS.—The incrustations occurring in *arid* and *semi-arid* regions on *alkali* soils, consisting of divers salts, but more particularly the carbonates and sulphates of sodium and calcium.

ALUMINA.—The oxide of the metal aluminum. It is the most abundant of the "earths" and is the characteristic constituent of clay.

ALLUVIAL.—Adjective of *alluvium* (which see).

ALLUVIUM.—A deposit of clay, *silt*, mud, or of the finer particles of sand, formed wherever the flow of a muddy stream is checked. It is found chiefly on *flood plains*, at river bends, at the mouths of streams as deltas. A very fertile type of soil.

AMENDMENT.—A soil modifier and improver; a material used to bring about a desirable change, a soil improvement. *Lime* is a soil amendment.

AMORPHOUS.—The reverse condition from crystalline; structureless, that is to say without special, fixed character. A rock is said to be amorphous when it is not of a crystalline character. Slate rock, for instance, is amorphous.

ARID.—Devoid or nearly devoid of rain-fall. The arid and semiarid section of this country is approximately that west of the one hundredth meridian, exclusive of certain portions of the Pacific coast.

ARIDITY.—State of being *arid*.

BIOLOGICAL.—Biology is the study of living matter, plant or animal; the science dealing with the structure, growth, development, distribution and functions of plants and animals, and the causes thereof.

CALCAREOUS.—Limey.

CAPILLARITY.—Capillary movement is that movement of water in soil, usually upwards but sometimes lateral, occurring between soil particles and through soil pores, caused by the attraction or pull of the solid matter of these particles for or on the fluid. The absorption of ink by blotting paper is due to capillary movement of the ink between the fibres of the blotting paper. Oil rises in the lamp wick for a similar reason.

CARBONATE OF LIME.—Combination of *lime* and *carbonic acid*, which see.

CARBONIC ACID GAS.—(Carbon di-oxid.) A common constituent of the air; used by plant life in building starch and other bodies; a combination of carbon and oxygen; the gas of the druggist's "soda water."

CHAMPLAIN CLAYS.—The residues of *glacial* action laid down by water in *post-glacial* times, particularly well illustrated in the Champlain valley.

CHEMICAL.—Chemistry is the science dealing with the interior composition of compounds, with special kinds of matter, with matter in the atom and molecule, as distinct from matter in the mass. The consideration of matter in the mass lies within the domain of *physics*.

CLASSIFICATION.—See page 705.

COASTAL PLAIN.—A margin of the land next to the sea or bordering or skirting on the coastline, extending backwards from the coast to the higher lands. The two great coastal plains of this country are the Atlantic and Gulf.

COLLUVIAL (cliff debris).—The sharp, angular, broken fragments of all sorts and sizes found at the base of cliffs.

CUMULOSE.—See footnote, page 708.

DEPOSITION.—The process whereby through natural accumulation, rock or soil material is laid down by wind or water. The opposite of denudation.

DIKING.—The shutting out of water by means of dykes or levees.

DILUVIAL.—*Alluvial* soil formed in ancient times.

DISINTEGRATION.—The decay and wasting away of rock structure under the effects of *weathering* and particularly of atmospheric agencies. The term is commonly applied and should be restricted to the *mechanical* changes in rock structure in contradistinction to its *chemical* destruction.

DISSOLVED SALTS.—A general term for chemicals (plant foods) dissolved by soil waters.

DRIFT.—An accumulation of clay, sand, gravel, pebbles, and boulders which has been moved by glacial action and deposited at the end or side of the *glacier* or beneath it. Sometimes called glacial drift, glacial deposits, *till*, (all of which see).

DURAM.—A name applied to certain macaroni wheats, especially adapted to growth in regions of light rainfall. They are notably able to withstand drought and heat, and give the best results on the great plains near the 100th meridian.

EEL GRASS.—A form of sea-weed growing wholly under water, grass-like in its appearance and extremely common near low water mark.

EXTERNAL AGENCIES.—Water, ice, wind, etc. (See pages 203-236, bulletin 143).

FELDSPAR.—The name of a group of minerals or rocks. Granites are composed of *quartz*, feldspar, and, usually, mica.

FLOOD PLAIN.—A plain which has formed the border of a stream and on which the stream has deposited *silt* when at flood. Ox bows are types of flood plains.

GEOLOGICAL.—Geology is the science dealing with the present condition of the structure of the earth, its *physical* forces, its past developmental and structural history, the causes and modes of *physical* changes, etc., and the occurrence and development of life.

GLACIAL.—Caused by action of the *glacier*.

GLACIAL DRIFT.—See *drift*.

GLACIER.—A field or stream of ice formed from compacted snow which moves slowly onwards over slopes and through valleys, eroding the territory over which it passes.

GYPSUM.—Land plaster, sulphate of lime. Mined in central New York, Nova Scotia and elsewhere. Commonly used in stables for the fixation of *nitrogen* as well as upon the soil as an amendment.

HEAT METAMORPHISM.—The passing of a material like rock from one form, shape, or character into another under the influence of heat of the earth.

HORNBLEND.—A common form of rock of complicated chemical and mineralogical character.

HUMIDITY.—Dampness; as the humidity of the atmosphere.

HUMUS.—A black or brownish soil ingredient, the resultant of vegetable decay; vegetable mold. Vegetable matter decaying is not humus; vegetable matter decayed is humus. Soil humus is discussed at length in bulletin 135, pages 153-175.

INORGANIC.—Not of plant or animal origin, in contrast with *organic* (which see).

INTERNAL AGENCIES.—Volcano, earthquake, crustal movements.

MARL.—A fine, limy, clayey or sandy mineral soil, relatively free from *humus*, which is sometimes used as a fertilizer. Usually a clay mixed with *carbonate of lime*.

METAMORPHOSIS.—The passing from one form, shape, or character into another.

LEDA CLAYS.—See *Champlain clays*.

LEGUME (leguminous).—Plants of the pea family, including peas, beans, clovers, etc.; characterized by a pod-like fruit, highly nitrogenous composition and the presence of root nodules inhabited by nitrogen gathering bacteria.

LIME.—Strictly a combination of calcium and oxygen; quicklime. Commonly used also for slaked lime (calcium, oxygen, water, etc.) (See bulletin 99 for discussion).

LIMESTONE FORMATIONS AND UPLANDS.—An upland *topography* of a limestone character found particularly in Kentucky, Tennessee and Missouri.

LOESS.—A deposit of fine textured clay loam and very fine sand found in many sections of the world, either water or wind formed.

MAGNESIA.—A compound of the elements of magnesium and oxygen.

MECHANICAL ANALYSIS.—A separation of a soil into its various parts as to size. That is to say, the separation of a sand into the various grades—coarse, medium, fine, very fine; of the silts and of the clays.

MORAINE.—The collection of rock and soil debris in ridges or humps at the edge or end of a *glacier*. The moraine is called a terminal or lateral moraine according to its location.

MUSKEG.—A rocky basin filled with successive deposits of such unstable materials as leaves, muck, moss, etc. Wild marshy tracts covered with moss and often bearing thick growths of conifers.

NITROGEN.—A gaseous element, constituting about four-fifths of the air; the central element of flesh structure and of protein.

ORGANIC MATTER.—Soil materials derived from life processes, as apart from those of rock origin; material capable on combustion of complete volatilization.

PALUDAL.—*Alluvial* soils formed by salt water agencies.

PERCOLATION.—The downward passage of rain water through the soil.

PHOSPHORIC ACID.—A combination of phosphorus with oxygen and hydrogen; a deficient ingredient of plant food. (See bulletin 99 for discussion).

PHYSICAL.—Pertaining to the properties and the forces and the phenomena of physical matters, more particularly in its energy relations. Its soil relations have to do particularly with moisture and heat.

PHYSIOGRAPHY.—Physical geography. A description of nature. That branch of geography which treats of the *physical* features of the earth, more particularly its surface and atmosphere and the form and character taken by that surface under the action of existing *physical* agencies, more especially the distribution and flow of water and of ice, the effect of atmospheric agencies and of the various forms of animal and plant life.

PLATEAU.—An extensive strip of elevated and comparatively level land; a table land. The plateaus in the soil provinces of the United States are Piedmont, back of the Atlantic coastal plain, and the Appalachian plateau, and those occurring in the Rocky Mountains.

POST-GLACIAL.—Occurring after the *glacier*.

POTASH.—Strictly a combination of potassium and oxygen. Commonly used to cover potassium in its various forms as employed in fertilization. (See bulletin 99 for discussion).

QUARTZ.—An extremely hard mineral composed, when pure, solely of *silicic acid.* The most abundant of all minerals. One of the three principal ingredients of granite.

RECLAMATION.—The act or process of reclaiming, in the special sense as used in this article, means to reclaim soils injured by natural or artificial causes.

RESIDUARY.—Resulting from local rock decay. The results of disintegration not having been transported. Pertaining to or having the nature of a residue or remainder.

ROCK METAMORPHOSIS.—See page 204, bulletin 143.

SEDENTARY.—See footnote, page 708.

SEDGE.—A coarse, grass-like, rush-like, or even flag-like plant growing in wet places on the banks of lakes, ponds, sluggish streams, etc.

SEMI-ARID.—Partially *arid;* somewhat lacking in rainfall.

SERIES (soil).—A grouping of soil types into a consecutively arranged set.

SHALE.—A clay rock readily cleft, the flakes of which are apt to be rather uneven.

SILICIC ACID.—A combination of the elemtns silicon and oxygen. The most common combination in the world. *Quartz* is silicic acid. Nearly three-fourths of the entire world structure consists of this material.

SILT.—A fine textured soil. Next to clay it is the finest of all soil in texture.

SOIL MAP.—A map of a given region on which soils of various types are indicated.

SOIL PROVINCE.—A grouping into vast areas of the divers soil series and miscellaneous types, depending upon certain soil similarities, due in part to the nature of the original material and in part to the principal agencies operating in their formation.

SOIL SURVEY.—A survey by actual visitation, inspection, sampling, etc., of divers areas all over the country with a view of determining nature, characteristics, and adaptations of soil.

SOIL TYPE.—One of a class or group of soils that most clearly embodies the essential characteristics of that group or class.

SOLUTION.—A liquid combination of a liquid and non-liquid substance. The change of matter from a solid or gaseous into a liquid state through its combination with liquid. Exactly what happens when a salt passes into solution is still a vexed question.

SPHAGNUM.—A form of moss particularly concerned in the formation of peat.

'ERMINAL MORAINE.—(See moraine). A *moraine* located at nd of a *glacier*. This term is applied to the deposits stretching ɜ the country from New Jersey to the State of Washington, mark-he end of the continental *glacier*.

'ERRACE.—A relatively narrow, horizontal shelf on the face of ı slope. Shore terraces are either wave built or wave cut. Stream :es are built by the stream.

EXTURE (textural).—The arrangement and character of the ɔnent parts or particles. The mode of disposition of the con-nt parts in the structure of any material in connection with each That method of arrangement and that character of the par- of a rock or soil which serve to distinguish it from others. e construction as distinguished from structure in its general As for instance, a slaty texture is very close, fine and compact, the texture of sandstone is relatively coarse.

[LL.—A heterogeneous mixture of clay, *silt*, sand, pebbles, cob-ɔoulders, deposited by the action of a *glacier* and unacted sub-ıtly upon by moving water. *Glacial* soil are either tills in the ion of their original deposition or are clays, gravel, etc., as ed by the subsequent action of moving water.

)POGRAPHY.—The *physical* features as a whole which charac- any region. For instance, Vermont's topography is uneven in ; is made up of mountains, hills and valleys. Nebraska's topo-ʳ, on the contrary, is flat.

ʀANSPORTED.—See footnote, page 708.

JLCANISM.—The phenomena attending volcanic action.

EATHERING.—The action more particularly of the air, and of l water or rock surfaces, causing them to disintegrate and to ɔose.

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